W06[15] $9.95
SILICON CHIP JAN 15
NDC 7T 29/12 1511
9 771030 266001 01

SILICON CHIP

JANUARY 2015
ISSN 1030-2662 01
9 771030 266001
PP255003/01272
$9.95* INC GST NZ$12.90 INC GST

MicroMite MkII:

- More memory
- More functions
- MUCH More speed!

Your first project!

Build a PICO MINI CUBE

INTERFACING TO THE BRAIN

... here's how it is happening RIGHT NOW!

Jaycar Electronics — Better. More Technical

KIT OF THE MONTH

Theremin Synthesiser Kit MkII

SILICON CHIP MAR '09 KC-5475

$74.95

The ever-popular Theremin is better than ever. Create your own eerie science fiction sound effects by simply moving your hand near the antenna. Easy to set up and build. Kit supplied with PCB with overlay, pre-machined case and all specified components.

- Requires 12V power supply (MP-3147 $17.95)
- PCB: 85 x 145mm

$14.95

Universal Power Supply Regulator Kit

SILICON CHIP MAR '11 KC-5501

This small board and a handful of parts will allow you to create either a regulated ±15V rail or +15VDC single voltage from a single winding or centre tap transformer (not included). Kit includes all PCB and components for board (transformer not included).

- PCB: 72 x 30mm

$16.95

Voltage Regulator Kit

SILICON CHIP MAY '07 KC-5446

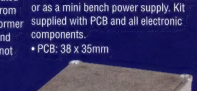
This handy voltage regulator can provide up to 1,000mA at any voltage from 1.3 to 22VDC. Ideal for experimental projects or as a mini bench power supply. Kit supplied with PCB and all electronic components.

- PCB: 38 x 35mm

"Burp" Battery Charger Kit

FOR NI-CD & NI-MH

SILICON CHIP MAR '14 KC-5527



$79.95

Charge one single cell or up to 15 in series connected cells (i.e. up to 18V). Fast charge, top-up, trickle and "burp" charge options. Kit supplied with double sided, solder-masked and screen-printed PCB, die-cast case (119 x 94 x 340mm), label and electronic components. Requires a power supply.

- Adjustable charging time-out
- Adjustable dT/dt (Temperature change rate cut-off)
- Adjustable charge current

AUTOMOTIVE KIT

10A 12VDC Motor Speed Controller

SILICON CHIP JUN '97

KC-5225

$24.95

Ideal for controlling 12VDC motors in cars such as fuel injection pumps, water/air intercoolers and water injection systems. The circuit incorporates a soft start feature to reduce inrush currents, especially on 12V incandescent lamps. Kit includes PCB and all electronic components.

- PCB: 69 x 51mm

$32.95

Universal Voltage Switch Kit

HIGH PERFORMANCE ELECTRONIC PROJECTS FOR CARS - SILICON CHIP PUBLICATIONS

KC-5377

Trips a relay when a preset voltage is reached. Can be configured to trip with a rising or falling voltage making it suitable for a wide variety of voltage outputting devices eg., throttle position sensor, air flow sensor, EGO sensor. Features adjustable hysteresis (the difference between trigger on/off voltage). Kit supplied with PCB, and electronic components.

- PCB: 105 x 60mm

$32.95

Economy Adjustable Temperature Switch Kit

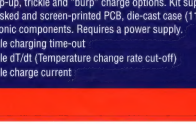
HIGH PERFORMANCE ELECTRONIC PROJECTS FOR CARS - SILICON CHIP PUBLICATIONS

KC-5381

Adjustable switching temperature up to 245°C, and can be configured to trigger with rising or falling temperature. Also used to operate cooling fans on a radiator or amplifier, over-temp warning lights or alarms, and much more. Kit supplied with PCB, NTC Thermistor, and all electronic components.

- PCB: 105 x 60mm

HOUSEHOLD KITS



$9.95

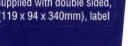
Water Level Sensor Kit KG-9138

LED will illuminate when two contacts are shorted by liquid. Ideal for applications such as an overflow alarm and rain detector. Connect Relay Card KG-9142 for a relay output to operate lights, sirens or other warning devices. Kit supplied with Kwik Kit PCB and all electronic components.

- Project requires 9VDC
- PCB: 28 x 17mm

ALSO AVAILABLE:

RELAY CARD KG-9142 **$9.95**



$29.95

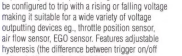
USB Port Voltage Checker Kit

SILICON CHIP JUL '13

KC-5522

An easy way to test a USB port to see if it is dead, faulty or incorrectly wired to help prevent damaging a valuable USB device you plan to connect. Voltage is indicated using three LEDs. Kit supplied with double sided, solder masked and screen-printed PCB.

- PCB: 44 x 17mm



$44.95

433MHz Remote Switch Kit

SILICON CHIP JAN '09

KC-5473

Suitable for remote control of practically anything up to a range of 200m. The receiver has momentary or toggle output and the momentary period can be adjusted. Up to five receivers can be used in the same vicinity. Short-form kit contains two PCBs and all specified components.

- Requires case and 9-12VDC power
- PCB: Tx: 85 x 63mm; Rx: 79 x 48mm

$49.95

Soft Start Kit for Power Tools

SILICON CHIP JUL '12

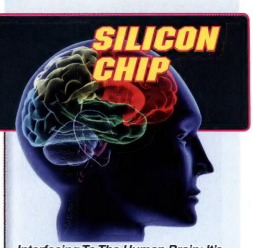
KC-5511

Stops that dangerous kick-back when you first power up an electric saw or other mains-powered hand tool to prevent damage to the job or yourself. Kit supplied with PCB, silk screened case, 2m power cord and specified electronic components.

- 240VAC
- 10A max load
- PCB: 81 x 59mm

Contents

Vol.28, No.1; January 2015 www.siliconchip.com.au



Interfacing To The Human Brain: It's Happening – Page 12.

Features

12 Interfacing To The Brain
Interfacing to the human brain might seem the stuff of science fiction but a great deal of work is being done in this area, as well as work on animals and insects. You can even do it yourself – by Dr David Maddison

20 The Micromite Mk.2
Introduced in our May 2014 issue, the Micromite is a small 28-pin chip running a powerful BASIC interpreter. Now we have the Micromite Mk.2 with more memory, more functions, higher speed and a host of other improvements – by Geoff Graham

84 Review: Tektronix RSA306 Real Time Spectrum Analyser
This spectrum analyser hooks up to a late-model PC, laptop or tablet via a "SuperSpeed" USB 3.0 cable and offers virtually all the features of a real-time spectrum analyser at a fraction of the cost – by Jim Rowe

Projects To Build

Isolating High-Voltage Probe For Oscilloscopes – Page 26.

26 Isolating High-Voltage Probe For Oscilloscopes
Measure AC mains and other high-voltages safely on your oscilloscope with this low-cost unit. It has three switchable input voltage ranges, wide bandwidth and high voltage isolation between input and output – by Jim Rowe & Nicholas Vinen

38 High-Energy Multi-Spark CDI For Performance Cars, Pt.2
Second article gives the full assembly details for six different versions to suit your car's ignition trigger source and describes the installation – by John Clarke

64 Currawong 2 x 10W Stereo Valve Amplifier, Pt.3
Final article describes the optional remote volume control, the laser-cut acrylic cover and the testing procedure – by Nicholas Vinen

76 Beginner's Project: The PicoMiniCube
It's powered by three 1.5V batteries and uses a PIC microcontroller to drive 27 LEDs to give an eye-catching 3D display. It's perfect for school projects and costs less than $28 – by Phillip Tallents & Ross Tester

Building & Installing The High-Energy Multi-Spark CDI – Page 38.

Special Columns

44 Circuit Notebook
(1) Using A Micromite To Control A PCF8563 Real-Time Clock; (2) Engine Immobiliser Uses An RFID Tag; (3) 4-Digit Thermometer; (4) USB OTG Charging Cable

58 Serviceman's Log
DIY printer repairs can easily go wrong – by Dave Thompson

90 Salvage It
Want to salvage and reuse common-mode chokes (CMCs) from faulty switchmode power supplies? Here's how – by Ken Kranz

94 Vintage Radio
The Stromberg-Carlson 5A26 radio – by Associate Professor Graham Parslow

The PicoMiniCube: A Fun Beginner's Project – Page 76.

Departments

2 Publisher's Letter
4 Mailbag
57 Product Showcase
83 Subscriptions
89 Online Shop
99 Ask Silicon Chip
103 Market Centre
104 Advertising Index

SILICON CHIP
www.siliconchip.com.au

Publisher & Editor-in-Chief
Leo Simpson, B.Bus., FAICD

Production Manager
Greg Swain, B.Sc. (Hons.)

Technical Editor
John Clarke, B.E.(Elec.)

Technical Staff
Ross Tester
Jim Rowe, B.A., B.Sc
Nicholas Vinen

Photography
Ross Tester

Reader Services
Ann Morris

Advertising Enquiries
Glyn Smith
Phone (02) 9939 3295
Mobile 0431 792 293
glyn@siliconchip.com.au

Regular Contributors
Brendan Akhurst
Rodney Champness, VK3UG
Kevin Poulter
Stan Swan
Dave Thompson

SILICON CHIP is published 12 times a year by Silicon Chip Publications Pty Ltd. ACN 003 205 490. ABN 49 003 205 490. All material is copyright ©. No part of this publication may be reproduced without the written consent of the publisher.

Printing: Hannanprint, Warwick Farm, NSW.

Distribution: Network Distribution Company.

Subscription rates: $105.00 per year in Australia. For overseas rates, see our website or the subscriptions page in this issue.

Editorial office:
Unit 1, 234 Harbord Rd,
Brookvale, NSW 2100.
Postal address: PO Box 139,
Collaroy Beach, NSW 2097.
Phone (02) 9939 3295.
Fax (02) 9939 2648.
E-mail: silicon@siliconchip.com.au

ISSN 1030-2662
Recommended and maximum price only.

Publisher's Letter

Petrol power tools are anathema

Now that we are in the middle of the Australian summer, part of the weekend ritual seems to be that everyone in suburbia needs to drag out their mowers and related paraphernalia to inflict a lot of unnecessary noise on the neighbours. Most of these mowers, whipper-snipper lawn edgers and leaf blowers are 2-stroke and are inevitably noisier and more polluting than the usually more expensive 4-stroke equivalent, if one is available.

But this noisy and polluting ritual is no longer necessary – you can use electric mowers and power tools instead. For some years now, I have used a mains-powered electric mower. I love it. It is much lighter than my not-so-old 2-stroke monster and indeed I can carry it up stairs and over fences with one hand! Nor is there any fiddling about with 2-stroke mixture, priming the carby and then pulling the retractable start. My petrol mower would typically start on the first try (due to regular maintenance!) but there are many men and women for whom starting such a mower is a virtually insurmountable physical hurdle, if it cannot be started quickly – they are simply not fit enough!

Not only is the electric mower no problem to start, it is much quieter. In fact, I don't need to resort to protective ear muffs. That brings about another advantage because not having to wear ear muffs means that you don't get so hot while you are doing the mowing. Nor do I have to put up with the smoky, smelly exhaust of a 2-stroke motor. In fact, mowing the lawn is a breeze and I have no qualms about doing it in the late afternoon after work (during daylight saving) because I know that the mower's noise will not disturb the neighbours. (I know that because two of my neighbours now have electric mowers too!)

There is one disadvantage in using a mains-powered electric mower and that is the power cord. You have to be vigilant at all times to make sure that the mower does not run over and cut the power cord. That has never happened to me fortunately but at the end of each run along the lawns, I have to swing the cord right out of the way, to make sure that it is well clear for the next run back in the opposite direction.

But if I was buying an electric mower today, I would not necessarily purchase a mains-powered version; I would carefully consider a lithium battery-powered model. These are still more expensive than mains-powered models but they are much lighter than the nickel-cadmium battery-powered models of only a couple of years ago. On the other hand, if you only have a small lawn, there are now small battery powered mowers which are very cheap. Mind you, actual mowing time capability does seem to be less than typically claimed and the way around this can be to buy a second battery pack (expensive!) or buy another power tool of the same brand with the same battery pack.

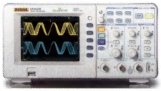
I also have a mains-powered electric leaf blower but sadly, I have to report that it is probably just as noisy as a petrol-powered job, albeit with the inconvenience of a power cord. I still prefer it though, because it does not have a smelly exhaust. Fortunately, I only use it about once a month so it is not a regular part of the weekend ritual.

So if you are a "weekend warrior", you should seriously consider pensioning off your petrol-powered mower and garden power tools. Not only is there less chance of losing your temper while trying to start the intractable beast(s), you will find the whole job much more enjoyable. You stay cool and your neighbours will like you better too. They may even follow your lead and change over to electric power as well. Isn't that a pleasant prospect? Have a quiet, peaceful weekend.

Leo Simpson

"Rigol Offer Australia's Best Value Test Instruments"

Oscilloscopes



RIGOL DS-1000E Series

- 50MHz & 100MHz, 2 Ch
- 1GS/s Real Time Sampling
- USB Device, USB Host & PictBridge

FROM $379 ex GST

NEW RIGOL DS-1000Z Series

- 50MHz, 70MHz & 100MHz, 4 Ch
- 1GS/s Real Time Sampling
- 12Mpts Standard Memory Depth

FROM $469 ex GST

RIGOL DS-2000A Series

- 70MHz, 100MHz & 200MHz, 2 Ch
- 2GS/s Real Time Sampling
- 14Mpts Standard Memory Depth

FROM $989 ex GST

Function/Arbitrary Function Generators

RIGOL DG-1022

- 20MHz Maximum Output Frequency
- 2 Output Channels
- USB Device & USB Host

ONLY $449 ex GST

NEW RIGOL DG-1000Z Series

- 30MHz & 60MHz
- 2 Output Channels
- 160 In-Built Waveforms

FROM $789 ex GST

RIGOL DG-4000 Series

- 60MHz, 100MHz & 160MHz
- 2 Output Channels
- Large 7 inch Display

FROM $1,059 ex GST

Spectrum Analyser

RIGOL DSA-815

- 9kHz to 1.5GHz
- 100Hz to 1MHz Resolution Bandwidth
- Optional Tracking Generator

FROM $1,499 ex GST

Power Supply

RIGOL DP-832

- Triple Output 30V/3A & 5V/3A
- Large 3.5 inch TFT Display
- USB Device, USB Host, LAN & RS232

ONLY $529 ex GST

Multimeter

RIGOL DM-3058E

- 5 1/2 Digit
- 9 Functions
- USB & RS232

ONLY $559 ex GST

Buy on-line at www.emona.com.au/rigol

Sydney
Tel 02 9519 3933
Fax 02 9550 1378

Melbourne
Tel 03 9889 0427
Fax 03 9889 0715

Brisbane
Tel 07 3275 2183
Fax 07 3275 2196

Adelaide
Tel 08 8363 5733
Fax 08 83635799

Perth
Tel 08 9361 4200
Fax 08 9361 4300

EMONA

email testinst@emona.com.au

web www.emona.com.au

MAILBAG

Letters and emails should contain complete name, address and daytime phone number. Letters to the Editor are submitted on the condition that Silicon Chip Publications Pty Ltd may edit and has the right to reproduce in electronic form and communicate these letters. This also applies to submissions to "Ask SILICON CHIP" and "Circuit Notebook".

Alcohol ignition interlock devices

I wish to comment on the use of ignition interlock devices, as discussed on pages 10 & 11 of the November 2014 issue. Some time in the mid 1980s I got involved in the preliminary investigation of an alcohol ignition interlock device. I had about 20 subjects, each of whom willingly consumed measured amounts of alcohol, after which I tried to measure their BAC (Breath Alcohol Content).

Indeed there was a difference between sexes but the differences between males were even greater! The correlations between my readings and actual blood alcohol content readings were surprisingly low.

The next problem I encountered was that of sensor contamination. The breath content of the previous test person would linger on and would add to that the next test person. Many a flushing technique, some quite inventive, were tried but we settled on a test person who had not consumed alcohol to test-blow the device. I admit this is not a terribly scientific approach.

The sensor worked within 10% when artificial breath (compressed air) mixed with alcohol fumes was used. The sensor was correct in detecting alcohol levels.

Then, one day, the non-alcoholic test person blew 0.2%. He had just consumed a sandwich, purchased in the local milk bar! Of course the test was repeated many times but in the end I had to admit defeat and cancel the project. The sandwich, by the way, was the standard composition of salad, onions, beetroot etc. Draw your own conclusions.

Ben Heij,
Little Mountain, Qld.

New software for Signal Hound spectrum analyser

As the owner of a Signal Hound SA44b and TG44 tracking generator since 2011, I was interested to read your review in the October 2014 issue of SILICON CHIP. There's no doubt that the hardware is a minor miracle, especially at the price and I have found it extremely useful in my home-construction activities.

There have been problems though, especially when using the matching TG44 tracking generator. Often the output level from the TG would not match that indicated and any attempt to change settings or abort a sweep could cause a crash. The "slow, high resolution" mode is very useful for 'digging down' into narrow crystal filters to reveal detailed responses etc but this mode is unstable and can crash with very little provocation.

To Signal Hound's credit, they have revised the software several times and things have improved, but the basic problems never seemed to go away. However, you may be interested to learn that new code has been written from scratch and is now undergoing final tweaks before a January 2015 release.

To get the new software just right, Signal Hound have canvassed the users of the SA44b and carefully noted their concerns over ergonomics and stability and the new software looks much slicker, quicker and user-friendly than before. There's a preview video on You Tube at **http://www.youtube.com/watch?v=pOQ0BN2CFZs**

KEYSIGHT TECHNOLOGIES | TRIO Test & Measurement
www.triotest.com.au | Call 1300 853 407

Keysight Technologies - The Smarter Choice in Hand-Held Test

Why? Keysight Technologies is the new name for Agilent's T&M business. Keysight' s world class measurement technology is tried, tested and trusted in bench applications.

Now you can enjoy the same high quality and value in a portable package by choosing one of our new handheld test-tools. From electronics troubleshooting to electrical installation and maintenance, Keysight handheld test-tools are tough, versatile, accurate and aggressively priced for amazing value. Make your smarter choice today!

DMM's, Insulation Testers, Process Meters, LCR Meters, Handheld oscilloscopes Clampmeters and more!

I hope this is of assistance to all those who may be considering the purchase of the SA44b.

Andy Howlett, G1HBE,
Cheshire, UK.

MEN system comments

The series on earthing to water-pipes was quite interesting. I am not a "sparkie" (but I do confess to replacing single GPOs with doubles) so I did not know that earthing to a pipe is illegal.

As for Sydney Water taking on the responsibility of correct earthing, I would say that it is because their employees and contractors are amongst those most at risk. In the meantime, I am still wondering where the earth stake is where I live. It's a new complex with a single meter board (padlocked, so I cannot check my usage) and no earth bond near it.

Finally, with respect to the Courtesy Light Delay published in the October 2104 issue, I can't but notice how they've advanced over the years. The first one I built was from an *Electronics Australia* circuit and consisted of a 2N3055 and an RC timer, wrapped in insulation tape and stuffed down the "B" pillar via the switch hole, on my old Ford Cortina (this was in the 1970s). Now we're looking at microprocessors for a similar function.

Dave Horsfall,
North Gosford, NSW.

Old wireless microphones may not be illegal in some areas

I have been following with some interest the information and articles in SILICON CHIP about wireless microphones. The local church in our town has a fairly old system though still functional, with one mic and a diversity receiver operating on 202.8MHz. In one of the articles in the magazine, it was stated that after 1st January 2015, wireless mics working in the VHF spectrum would not be legal.

I searched the ACMA website and could find no reference confirming this, so I sent an email to the ACMA asking if we could still use our system after the cut-off date in light of the fact that the frequency was not occupied by a digital television station in Adelaide. There are no stations on channels 9 and 9A in Adelaide.

The reply came back very promptly (the morning of the next business day) from a Spectrum Engineering Manager, saying that as the channels were vacant and there are no plans for TV stations on these channels in Adelaide, we could continue to use our system. There are DAB+ radio stations in Adelaide on 203.872-207.120MHz so our wireless mic won't affect, and hasn't been affected by, digital radio either.

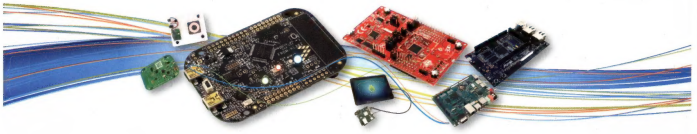
Keith Gooley,
One Tree Hill, SA.

Potential shorted turn in Currawong power transformers

I refer to the second article on the Currawong Stereo 10W Valve Amplifier in the December 2014 addition of SILICON CHIP. I would like to point out a potential trap and save someone from cooking the two power transformers.

As shown on pages 91 & 93, earth

Find your next Development Kit at element14



Our ever-expanding range of solutions offer everything you need at any stage of your design. From starter kits to complete development boards and tools, we always have the newest releases for Embedded, Analog, Sensing, Wireless and Lighting Dev Kits from leading brands.

In addition, we collaborate with world-class manufacturers to provide a comprehensive range of ARM®-based and ultra-low power development kits with development solution ecosystems that allow customers to bring their designs to market faster.

View our full product range at au.element14.com/devkits

4D SYSTEMS · ANALOG DEVICES · Atmel · beagleboard.org · freescale · Lattice · MICROCHIP · NXP · Raspberry Pi · ST · TEXAS INSTRUMENTS

CONTACT US TODAY!

WEBSITE: au.element14.com
PHONE: 1300 361 005
SALES: au-sales@element14.com

element14

OCEAN CONTROLS

Helping to put you in Control

LogBox RHT 32K Readings

IP65 dual channel data logger with built-in temperature & humidity sensor. It can be easily programmed and configured via a handy IR-LINK 3 interface which connects to a USB port under Windows® software or PDA IrDA interface. Replacable internal lithium (3.6V ½ AA) battery.

SKU: LOG-005 **Price:$159 +GST**

Any-Direction Microswitch

Industrial microswitch with springy actuator triggers when the actuator is pushed or deflected in any direction. This makes it trivial to mount in a wide variety of situations.

SKU: HES-204 **Price:$12.95 +GST**

10-Port USB Charging Hub

10 dedicated USB ports with a massive 60 W built in power in a compact design. 2 selectable types of charging current, 1 A or 2 A, 240 VAC powered.

SKU: UHB-003 **Price:$89.95 +GST**

USB Serial Stepper Controller

Four axis stepper motor controller fitted with USB and RS-485 ports. Takes simple serial commands and produces ramped frequency profiles for stepper or servo motor control. Revised version can be 8 to 35 VDC powered and has analog inputs.

SKU: KTA-290 **Price:$79 +GST**

Power Multiplexer Carrier

The Texas Instruments TPS2113A autoswitching power multiplexer allows you to switch seamlessly between two power sources of 2.8 V to 5.5 V, while blocking reverse current into either source & and the board also breaks out a USB Micro-B connector that can be used to supply one of the rails. It has an adjustable current up to 2 A.

SKU: POL-2596 **Price:$9.95 +GST**

Bluetooth 4.0 BLE Shield

Bluetooth Low Energy (BLE) shield for Arduino based on the Nordic Semiconductor nRF8001. This shield lets your Arduino talk to your smartphone or other Bluetooth 4.0 equipped devices. 3.3 V or 5 V powered.

SKU: SDA-001 **Price:$34.95 +GST**

New MeanWell Slim Line Series

MeanWell has recently announced the released of their highly anticipated new slim line series: EDR-120, NDR-120 & EDR-150. Only EDR-120 & NDR-120 offers standard output such as 12 VDC, 24 VDC and 48 VDC. EDR-150 is currently only available with 24 VDC output, but can be adjusted up to 156 W. These series will be available in late October. Contact us via phone, fax or e-mail to place your preorder. Price starting from $35 ea + GST.

For OEM/Wholesale prices
Contact Ocean Controls
Ph: (03) 9782 5882
oceancontrols.com.au

Mailbag: continued

True science is always questioned

I just read with interest both my letter and Robert Suhr's in the Mailbag pages of the November 2014 issue. He may have been angry enough to have stopped his subscription but you have recently gained me as a subscriber for sticking to true questioning of science.

While I once believed in the dangers of Global Warming , I have given this the due diligence to investigate the so-called "science" and what it was based on. Climate science has become a farce, with government grants being withheld and jobs being on the line if government political agenda using science was not backed. Valid scientists are of different opinions to the warmists. A study of the IPCC themselves makes interesting reading. See this link at http://tinyurl.com/SillyCon-Scam2

How on earth can it be called science when the numbers they collate can back any conclusion they wish to pull out of their collective hats? There are far-fetched conclusions of acidification of rising oceans, claims of extinctions when actual science is not yet truly understood and they readily jump to unproven conclusions. And the Australian Bureau of Meteorology has "homogenised" temperatures previous to 1906 (currently being investigated by parliament – see http://jennifermarohasy.com/temperatures/).

Marohasy's research has put her in dispute with the BoM over a paper she published with John Abbot at Central Queensland University in the journal *Atmospheric Research*, concerning the best data to use for rainfall forecasting (she is a biologist and a sceptic of the thesis that human activity is bringing about global warming). BoM challenged the findings of the Marohasy-Abbot paper but the international journal rejected the BoM rebuttal, which had been prepared by some of the bureau's top scientists.

Sea levels are not rising as they are mostly within the bounds of errors of measurements. Elusive numbers are used and actually found to be inside normal margins by an Australian scientist, Doug Lord, who was made redundant after disagreeing with the government's claim of a 100-metre sea level rise and he was a climate change believer. Other CSIRO scientists have quit due to disagreements based on the institute's policy.

I fully support the Editor of SILICON CHIP.

John Vance,
Wangaratta, Vic.

wires are connected to the bolts holding the transformers. In this case, all is OK as they are mounted in the timber plinth. But if someone was to mount them on a metal chassis, this would be when disaster strikes.

I did this on an amplifier I built years back, thinking it was a good idea to connect the earth wires like this. When I switched on with no load connected, there was a loud hum followed by a wisp of smoke just as I switched off. I could not work out why as the transformers secondary windings were not yet connected; I was just checking out the transformer to see if all the voltages were OK.

After looking at it for a while the penny dropped; the earth wires make a complete turn of thick wire with no resistance to the magnetic field of the transformer and thereby overload it.

David Francis,
Kilburn, SA.

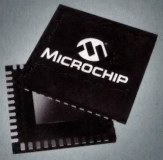
Comment: you are absolutely correct. Earthing the transformer bolts in an already earthed metal chassis constitutes a classic shorted turn which could easily burn out the primary winding when power is applied.

In the case of the Currawong though, the immediate effect would be to blow the 1A slow-blow fuse in the IEC mains socket so no damage would be done but there would inevitably be some head-scratching by novice constructors.

Nor is it really necessary to have the bolts earthed in the timber plinth, especially as the transformers should

dsPIC® DSC Motor Control Family Increases Energy Efficiency

- High-performance core with DSP instructions for precise control
  - Variable speed with constant torque using PI controllers
  - Field oriented control (FOC) for greater efficiency
- Industry-leading motor control PWM modules
- High-performance on-chip op amps
- Intelligent, high-speed ADC
- Algorithms and Application Notes for BLDC, PMSM and ACIM motors
- Field oriented control and sensorless control algorithms
- Certified Class B safety software
- Dual motor control with FOC on both motors
- Multiple package options, ranging from 28–144 pins
- Scalable motor control tools with low- and high-voltage options



Microchip Technology Australia
Tel: 61-2-9868 6733 E-mail: aust_nz.inquiry@microchip.com

microchip DIRECT
www.microchipdirect.com

MICROCHIP

microchip.com/motor

The Microchip name and logo, the Microchip logo and dsPIC are registered trademarks of Microchip Technology Incorporated in the U.S.A. and other countries.
All other trademarks are the property of their registered owners. © 2015 Microchip Technology Inc. All rights reserved.

Silvertone

SIGNAL HOUND

USB-based spectrum analyzers and RF recorders.

SA44B: $1,320 inc GST

- Up to 4.4GHz
- Preamp for improved sensitivity and reduced LO leakage.
- Thermometer for temperature correction and improved accuracy
- AM/FM/SSB/CW demod
- USB 2.0 interface

SA12B: $2,948 inc GST

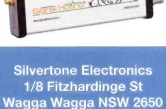
- Up to 12.4GHz plus all the advanced features of the SA44B
- AM/FM/SSB/CW demod
- USB 2.0 interface

The BB60C supercedes the BB60A, with new specifications:

- The BB60C streams 140 MB/sec of digitized RF to your PC utilizing USB 3.0.
- An instantaneous bandwidth of 27 MHz.
- Sweep speeds of 24 GHz/sec.
- The BB60C also adds new functionality in the form of configurable I/Q.
- Streaming bandwidths which will be retroactively available on the BB60A.

Vendor and Third-Party Software Available.

Ideal tool for lab and test bench use, engineering students, ham radio enthusiasts and hobbyists. Tracking generators also available.



Silvertone Electronics
1/8 Fitzhardinge St
Wagga Wagga NSW 2650
Ph: (02) 6931 8252
contact@silvertone.com.au

Mailbag: continued

Alternative 433MHz module is ideal for sniffing

With respect to the query about 433MHz sniffing on page 99 of the September 2014 issue, Jaycar's new ZW-3102 433MHz data receiver (based around Princeton Tech's PT4302 RF IC), is pin-for-pin compatible with their traditional ASK module. Aside from their intended data duties, band "sniffing" persuasion gives piezo-based audio that also seems superior in both in volume and clarity to their classic Keymark offering.

The module especially scores over Dorji's cheaper 433MHz receiver for its ability to work down to 2.4V. Such a flexible supply nicely suits powering by a single Li coin cell, single $LiFePO_4$ cell, two alkaline AA cells etc.

It's shown itself to be significantly more sensitive than the old module. Semi line-of-sight signals (through light vegetation and wooden buildings) from a 25mW tone-sending Dorji transmitter were still audible when some 100m away.

Data sheet sleuthing reveals a signal strength point at PT4302 pin 14, which conveniently runs to a good solder point at SMD capacitor C5. A wire can be run from this to a duplicated module data pin that's freshly isolated (by PCB track cutting).

The voltage swing here suits useful RSSI work, as it varies between 0.9V with just band noise and ~1.4V with a strong nearby signal. DMM monitoring here could allow keen insights into transmitter, propagation path and antenna performance. A simple LED (perhaps wired via a boosting Darlington transistor) however could be enough for proximity and visual checking on such suspect transmitters as 433MHz wireless doorbells.

As these ZW3102 modules are available off the shelf at any Jaycar store they may be worthwhile for general 433MHz use, even though they're more costly than other offerings.

Stan Swan,
Wellington, NZ.

be mounted with a large rubber washer (which is supplied) underneath the large steel washer. And in the case of an earthed steel chassis, there would be no need at all to separately earth the transformer mounting bolts because they would be earthed by the steel chassis itself.

PWM motor whine can be fixed with an LC filter

In the "Ask Silicon Chip" section of December 2014, on page 114, reader J. E. has a problem with whine from a PWM-driven fan. I have designed a number of PWM motor controllers and initially experienced the same problem years ago but it is easily solved with an LC low-pass filter.

A bobbin style inductor of 100µH to 220µH is inserted between the driving Mosfet or transistor and the motor, followed by a capacitor across the motor wires close to the inductor. The capacitor is sized so that its reactance is substantially less than the inductor at the PWM frequency, eg 1/10th.

Most people will not be familiar with the maths so the easy way is to try various values until the motor is quiet. My designs have used values ranging from 100µH & 1µF to 220µH & 220µF, with low-ESR capacitors.

George Ramsay,
Holland Park, Qld.

Choice of line output transformer in Currawong

Your Currawong Stereo Valve Amplifier is interesting. Last year, I used a line transformer to repair a 1960s *Electronics Australia* Playmaster Unit 4 Stereo Amplifier that had an open-circuit in one of the output transformers.

After reading the articles by Paul

Cambie, Grant Wills and Roly Roper in OzValveAmps on using line output transformers, I decided to have a go at fixing the old Playmaster unit as I had a spare Altronics M1130 40W transformer. Even though the originals were only rated at about 10W, they were much heavier (940g compared with 540g for the M1130). The M1130 fitted easily and even the hole spacings matched. I used an 8-ohm load on the 2-ohm output to run it as 8kΩ (plate loading). The original circuit specified 9kΩ but I decided that this was near enough.

The stereo unit probably gives the best possible comparison as you can hear both channels at the same time, rather than try to remember what it sounded like. My wife and I independently concluded that the M1130 channel had more treble and slightly less bass than the channel with the original Ferguson OP412 output transformer. The M1130 actually ran cooler than the original.

As a replacement for an unobtainable part, the line transformer is an excellent way to keep a 50-year old amplifier running but I think that you have tried to be a little too cheap in the Currawong. I built a pair of 807 valve amplifiers based on the "Triode Connected 807 Amplifier" described in *Radio & Hobbies* 1948 (the sound quality is stunning) and a large guitar amplifier with EL34s and there is no substitute for copper wire in the output transformers. As the OzValveAmps article suggests, the small M1115 transformers will probably run quite warm and the 40W M1130 would match a pair of 6L6s.

Leo Simpson has resisted publishing valve amplifiers

Mailbag: continued

TempMaster Mk.3 works very well

Well done on the excellent TempMaster Mk3 (SILICON CHIP, August 2014) kit! I'd recently purchased a deep freezer from a well-known German retailer at what I thought was a bargain price. The freezer had a 3.5 star rating and from all my research that was about the best to expect from freezers.

Unfortunately, every time I walked past the unit, it always seemed to be continuously running, irrespective of what setting the thermostat was at. I ended up measuring the temperature and found it to be at -36°C (or even lower at times), which was way too far from the optimum -18°C.

I ended up building the TempMaster Mk3 and fitted it to the freezer. In no time flat, it was a breeze to set the temperature to the optimum -18°C. I'm looking forward to the lower running costs thanks to this great project. Keep them coming!

Peter Kutas,
Shortland, NSW.

for decades because they just cannot match modern amplifier designs on sound quality, price, safety and ease of construction. Unfortunately, I don't think that your choice of output transformer in the Currawong amplifier will help convince him or many of your readers. Your design does limit most of the safety risks and a circuit board is a thousand times easier than point-to-point wiring.

I know this from experience as the two 807 amplifiers look like mirror images but the valve pins and therefore the circuits are not. It actually took longer to build the second one as I had to completely "unthink" the first circuit.

The blue LEDs in the Currawong might not be needed. When I first built my amplifier, the 807s emitted a beautiful eerie blue glow, probably with lots of UV (the 6L6 or KT66s might also). This glow has faded over 10 years.

Unfortunately, the eight valves alone will push the price to $300 and the other components and board will add hundreds more. There is no advantage saving $25 by using the cheapest transformers (the M1130 are each about $12 more) or even $100 (compared with genuine output transformers such as Hammond or those made in Australia).

It would be sad if you disappointed a generation of hobbyists who have heard just how good a valve amplifier can sound. I don't mean good valve amplifier sound, I mean good amplifier sound. Why not run a series of comparisons to see if my suggestions do actually improve the final sound? You suggest that different transformers could be used to raise the output; why not give your builders some definite evidence.

As well as hifi enthusiasts, I am sure that there are hundreds of guitarists drooling over the prospect of a "toob" guitar amplifier design. Custom tone control and selective distortion are

Wabeco Australia
wabeco.com.au
deals@wabeco.com.au

German made
Highest precision
5 year warranty

5% discount for all SILICON CHIP readers unti 30-Apr-15

Wabeco D6000 Lathe
90-10601
~~$8,949~~
$8,499

High speed version available
Camlock version available
CNC version available
Ball screws available
Accessories available

Price is correct at time of printing but subject to change without notice due to exchange rates.

High-power LED modules can be over-rated

Those that are interested in building their own high-powered LED lighting will be aware that LED modules of up to 100W are available. I recently purchased one of these via eBay and confirmed its operation and left positive feedback. It was only later after I had modified a heatsink to suit it to allow me to run the device at full power that I became aware that it was, in fact, a 50W unit.

Despite plenty of power being available, it would only draw around 1.5A at its maximum rated voltage of 35V when it was rated at around 3A at that voltage. Unfortunately, many or even most of these devices seem not to have any identifying marks on them so that you can easily to determine their power rating or other specifications. Having had generally good experience on eBay with well-selected sellers, I am inclined to think it was an honest mistake because the seller was similarly unable to identify the device.

Dr David Maddison,
Toorak, Vic.

more important than flat response and S/N ratio. A guitar amplifier design would be very popular and less likely to disappoint. Thanks very much. I hope the amplifier design does go well.

Dave Dobeson,
Berowra Heights, NSW.

Comment: we think your choice would probably be OK if you were not using an ultra-linear connection. The Playmaster Unit 4 did use an ultra-linear circuit, so we would regard the M1130 line transformer as not the best transformer substitution and we would recommend the one we used in the Currawong. We did obtain a sample of the Altronics M1130 transformer and we concluded that we could not achieve symmetrical screen connections.

The line transformers we used run warm but not hot to the touch.

Ultimately, the very best valve amplifiers were designed on similar lines to the Currawong. Examples are the Mullard 5-10, 5-20 and Twin-Ten. All of these used ultra-linear push-pull operation and typically achieved total harmonic distortion below 0.1%. That was regarded as a benchmark and if we can achieve comparable or better results in the Currawong, the audible sound quality should be in line with those results.

We don't deny that a better (far more expensive) output transformer may improve the performance but we also think that any audible improvement would be relatively small.

It is true that the blue LEDs are not necessary. We only included them for cosmetic effect. However, the blue or indigo glow from some power valves is not all that common and typically does fade as the valve ages.

Finally, we do think that the Currawong sounds quite on a par with other good valve amplifiers. But it is no match for the exceptional sound quality of the SILICON CHIP 20W Class-A or Ultra-LD solid-state amplifiers. **SC**

ICOM

IP 100H

Icom Australia has released a revolutionary new IP Advanced Radio System that works over both wireless LAN and IP networks.

The IP Advanced Radio System is easy to set up and use, requiring no license fee or call charges.

To find out more about Icom's IP networking products email **sales@icom.net.au**

WWW.ICOM.NET.AU

ICOM0001

INTERF TO THE

While interfacing to the human brain might seem the stuff of science fiction, there is much work being done in this area, as well as work on animals and insects. You can even do it yourself and it can have many practical aspects.

by DR DAVID MADDISON

Science fiction is full of scenarios in which a person's own brain is interfaced directly to a computer or a machine (or another person) and is used to interact with, or control it.

Examples include the people in *The Matrix* trilogy, the Daleks in *Dr Who* and the Borg in *Star Trek*.

And who can forget that 1983 sci-fi film *Brainstorm*, the whole theme of which was the development, use (and misuse) of a Brain-Computer Interface (BCI). BrainStorm can be viewed on YouTube at http://youtu.be/cOGAEAJ4xJE.

In this article we will primarily focus on methods of interfacing the human brain with computers and machines, so called brain-computer interfaces or BCIs. Australia is a world leader in the Cochlear implant but these devices do not interface directly to the brain. Rather, they connect to existing nerve fibres and are in the related category of neuroprosthetics.

A brain-computer interface can be defined as a system for reading information from the brain to enable control of a machine or the transmission of an item of communication or thought. It is also a system of feeding information into the brain to enable the brain to interpret a sensation from some external sensory device.

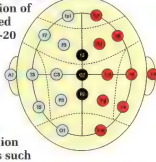
In other words, information is transmitted to and from the brain to a machine without the engagement of the usual senses, the peripheral nervous system or limbs.

Reading the brain

To interface the brain to a computer, information has to be first read from the brain. There are several means by which information can be acquired from a brain for the purpose of brain-computer interfacing.

Electroencephalography (EEG) has the advantage that it is relatively cheap and simple to do and can provide useful information in a clinical setting. It is also non-invasive and so is amenable to a wide variety of brain computer interfacing techniques, provided useful information can be obtained. There is a distinct advantage that changes in brain activity can be read very rapidly compared to other slower methods that rely on a change of blood flow, such as functional magnetic resonance imaging (fMRI), for example.

EEG also has a number of disadvantages. A scalp-re-



An EEG headset, as used in a clinical setting. Worldwide, the location of EEG electrodes is standardised according to the so-called 10-20 system (see right) whereby electrodes are positioned according to anatomical landmarks. Results from different researchers will therefore correspond to the same electrode locations (there are also higher resolution electrode placement schemes such as the 10-5 system and others). In clinical applications typically 19 electrodes are used plus an earth and system voltage reference. The voltages measured are of the order of microvolts and are amplified by 1,000 to 100,000 times.

ACING BRAIN

... yes, it is really happening!

corded EEG represents a coarse measure of brain activity due to the poor electrical conduction and thickness of the skull and the subsequent dispersion of electrical signals. It only measures the collective excitation of large numbers of neurons behaving in a synchronised manner that also happen to be oriented in the correct direction to provide an electrical signal that conducts toward the scalp. Individual neurons or small groups of neurons cannot be read directly.

The EEG output consists of rhythmic signals in various frequency ranges and also transient activity. Typically (but not always) these rhythmic signals are classified in terms of a number of frequency bands. These are usually Delta (<4Hz), Theta (4-7Hz), Alpha (8-15Hz), Beta (16-31Hz), Gamma (32+Hz) and Mu (8-12Hz). All these bands are associated with a certain biological significance and activities in the brain.

Electrocorticography

Electrocorticography (ECoG) is a form of EEG in which the electrodes are placed on the surface of the brain (cerebral cortex). It has the advantage that much higher spacial resolutions can be obtained and the sampling of much smaller groups of neurons. Different types of electrodes can also be used.

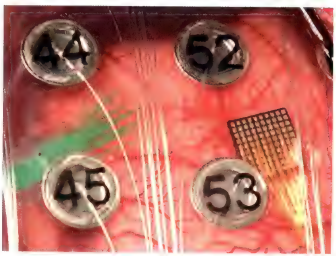
Of course, it has the distinct disadvantage that it is intrusive and requires the skull to be opened. For the purposes of brain computer interfacing it would only be done (at this point in time) for life-critical applications such enabling a quadriplegic to operate a robotic arm or wheelchair.

Electrical activity in the brain

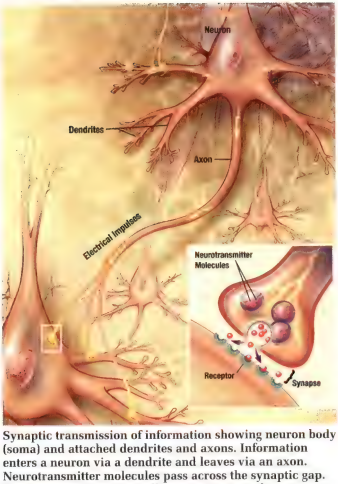
The brain consists of specialised cells called neurons and glial cells. The neurons are the cells responsible for information processing while the glial cells mostly have support roles.

Neurons are electrically active and can communicate with other cells in the brain by a branched conducting fibre called an axon that extends from the body of the cell and which can communicate with many other nearby or far away neurons. Neuron to neuron communication constitutes the essence of how the brain works.

The architecture of this connectivity between neurons



Research conducted at the Brain Institute at the University of Utah showing three types of electrocortical arrays in simultaneous use. The numbered electrodes are part of an ECoG array sitting on the surface of a human brain, the green wires terminate in a micro-ECoG grid and the black square with the gold-coloured electrodes is a "Utah Electrode Array" (UEA) which has an even finer resolution than the micro-ECoG grid. In this work the electrodes are used to discover and remove areas of the brain responsible for epileptic seizures but data read from such electrodes can also be used, for example, to convert speech-related brain signals into words, control machinery such as a robot arm, a wheelchair or even an aircraft or to work in any other application requiring a direct brain-computer interface. Note that while it is obviously an invasive procedure to have such electrodes implanted beneath the skull, these particular electrodes sit on the surface of the brain and do not penetrate it where damage may be done in sensitive areas.



Synaptic transmission of information showing neuron body (soma) and attached dendrites and axons. Information enters a neuron via a dendrite and leaves via an axon. Neurotransmitter molecules pass across the synaptic gap. Each electrical impulse will cause a connected neuron to be either excited or inhibited. The collective excitement or inhibition of very large numbers of neurons is what can be detected by an EEG signal.

is known as a neural network.

The way axons transmit electrical signals is by means of electrochemical pulses involving sodium and potassium ions being transported in different directions through the neural cell membrane. These electrochemical pulses are known as action potentials and typically last less than one millisecond and propagate at speeds of 1 to 100 metres per second.

Some neurons are inactive most of the time while others may be constantly active and fire at a rate of 5 to 50 times per second. A neuron's axon is connected to other neurons via junctions called synapses which make contact with another part of the neuron's body called the dendrite. There is a very high level of connectedness; each axon may have many thousand synaptic connections to neurons or possibly other cell types.

According to the latest estimates the human brain has an average of 86 billion neurons and 100 trillion synapses. The axons are the "wires" that connect most of the functional elements of the brain with each other.

Once an electrical signal or action potential arrives at a synapse, specialised chemicals known as neurotransmitters are released and these bind with the target neuron or other cell.

Many different neurotransmitters exist (around 100 have been identified so far) and can exert many different simple or complex influences on the target (or post synaptic) neuron but fundamentally will cause the post synaptic neuron to be either inhibited or excited.

As each neuron is connected to large numbers of other neurons the total numbers of inhibitory or excitatory signals received will determine whether that neuron will either not fire or fire and not pass or pass information to the next neuron in the network, and so on.

Many of these synaptic junctions are dynamically reconfigurable by changing the nature of the signals that travel through them and are thought to be involved in learning and memory.

Since the connections are not "set in stone", some reconfiguration of the brain is possible and this is the basis of neuroplasticity, the ability of the brain to reconfigure itself to compensate for damage.

This plasticity has only been seriously recognised in recent years and also suggests that electrode placement for the purpose of brain-computer interfacing is not extremely critical. It suggests that the brain will eventually be able to learn how to control an interface no matter where in the brain it is located (within reason) by a sufficient amount of learning.

Electrical signals in the brain or action potentials are the way neurons communicate with each other. Action potentials are subject to some basic but important rules. Firstly, there is a minimum threshold voltage below which no signal will be propagated along an axon so electrical "noise" will not cause signals to propagate.

Secondly, it is "all or nothing"; each action potential has the same strength, independent of the strength of a stimulus. Thirdly, there is a refractory period after the action potential in which no further action potentials can be generated. This helps ensure that the action potential propagates in only one direction and not back to its point of origin.

Most people are familiar with the terms "grey matter" and "white matter". If one takes a cross-section of a human brain, it will be seen that the outer layers are dark in colour (grey) while the inner parts are light in colour (white). The difference arises from the fact that axons are lighter in colour due to their insulating myelin sheaths while neurons are darker in colour. These colour differences show that the outer parts of the brain contain mostly neurons and the inner parts of the brain contain mainly axons or the "wiring" of the brain.

Non-invasive brain interface

While EEG and other methods can be used to read information from the brain, the information has to be meaningful and somehow express the subject's intent if they are to do something useful like control a machine. Like any new task, practice is necessary so that the appropriate synaptic connections can be strengthened in order to learn the desired behaviour. The following methods describe ways BCI devices can be controlled without intrusive implanted electrodes.

An EEG signal can be influenced by imagined movements and biofeedback methods whereby an individual learns with many training sessions to influence an EEG signal in a way that can be detected and used to drive a machine. Silent vocalisation of words can also be sensed and used to drive the interface.

The Steady State Visual Evoked Potential (SSVEP) is

a control system whereby a subject looks at one or more flashing screens or symbols. The signal from the flash is relatively easy to detect in an EEG signal and the intent of the subject can be inferred from the frequency of the flashing area they are looking at. It may be annoying for people to use, however.

The P300 wave, or more specifically now known as two waves, the P3a and P3b, are another way information can be read from the brain. These occur after a low probability event is observed and recognised among a series of "standard" events. These waves are useful to monitor for brain-computer interfacing because they are relatively consistent across most people and using them can be learned with minimal training.

One example of using this brainwave for communication in the disabled is the use of a P300 matrix speller. A test subject is presented with a 6x6 matrix of letters and numbers and individual rows and columns are illuminated in a pseudo-random manner. The subject selects a letter by concentrating on the character they want and their P300 wave is detected at that time.

Using this method with a scalp EEG results in letter selection rates of 1.4 to 4.5 characters per minute. This was able to be increased to 17 characters per minute by Peter Brunner and others in 2011 with an implanted 96-electrode array. Hybrid systems have also been developed combining the SSVEP mentioned above and the P300. See YouTube video **http://youtu.be/08GNE6OdNcs** *"Emotiv BCI2000 Video.mp4"*.

Writing information to the brain

Mentioned above were several methods that could be used to read information from the brain. It is also possible to "write" information to the brain. This can be done via implanted electrode arrays, transcranial magnetic stimulation (TMS) where a powerful magnetic field is pulsed through the skull or focused ultrasound (FUS) where a focused ultrasound beam is transmitted through the skull. All these methods excite groups of neurons within their field of influence and cause them to fire.

The earliest experiments with interfacing animal brains to machines happened in 1969. The experiment was by E.E. Fetz at the University of Washington School of Medicine in Seattle and involved training a monkey to move a biofeedback meter needle by activating neurons in its motor cortex, the region of the brain responsible for the execution of movement. The activity of these neurons was read from an implanted tungsten micro-electrode.

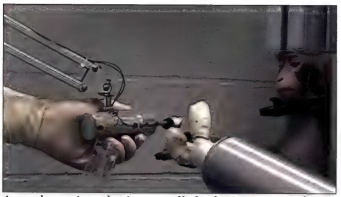
Following work by Fetz in interfacing a monkey brain to a machine, in the 1980s Apostolos Georgopoulos at Johns Hopkins University found a mathematical relationship between the electrical signals from motor cortex neurons and the direction the animal wished to move.

This lead to the development of computer models that relate movement to neural signals and are the basis of models that now translate complex neural signals into commands to operate machines such as robot arms.

Monkey controls robot arm

Professor Miguel Nicolelis from Duke University in North Carolina was the first to interface a monkey brain to a robot arm which it could move.

By 2000 the group had managed to reproduce a monkey's arm motion in a robot arm by monitoring neural signals from the monkey. The monkey had no direct control over the arm, it just reproduced its movements.



A monkey using a brain-controlled robotic arm to grab food to feed itself. The monkeys were able to effortlessly control the robot arm as though it were a natural part of themselves.

Subsequently, monkeys first trained to reach and grab objects on a computer screen using a joystick. This joystick also controlled a robot arm which the monkeys could not see. They were learning the simply task of moving things in two dimensions on the computer screen before being shown the actual robot arm which could move in three dimensions which the monkeys learned to control.

In this work an electrode array monitored an area on the motor cortex of around 50 to 200 neurons.

Other groups have done similar work and a group lead by Andrew Schwartz at the University of Pittsburgh in 2008 interfaced a monkey to a robot arm with an electrode array which recorded signals from 15-30 neurons and which enabled the monkey to feed itself.

A video of a monkey operating a robot arm can be seen at **http://youtu.be/gnWSah4RD2E** *"Monkey controls robotic arm with brain computer interface"*.

Visual imagery from the brain

Although the stuff of science fiction, scientists are mak-

Open-source brain computer interface

There is a successfully funded Kickstarter project called OpenBCI to develop an open source platform to enable anyone with an interest to monitor their own or another person's brainwaves via a wearable EEG monitor with a view to developing products controlled by the brain. Each board supports eight electrodes but these can be daisy-chained together to increase the electrode count.

Apart from the electronics and software there is also a 3D printable headset to mount the electronics package. See **http://openbci.com/**

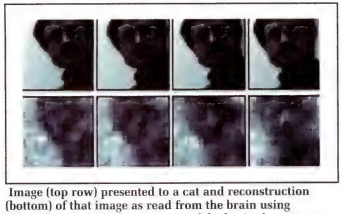


Image (top row) presented to a cat and reconstruction (bottom) of that image as read from the brain using electrodes implanted in a region of the brain that processes visual information.

ing good progress in reading visual imagery from inside the brain. Examples include reading images seen by the eye directly from the brain and also determining some content of dreams.

In one of the first demonstrations of reading visual imagery from a brain a cat had electrodes implanted in its brain and it was made to watch various scenes. The data from the electrodes was processed with some basic mathematical filtering and the original image was reconstructed.

It certainly seems from the reconstructed images, however, that the animal imposed its own cat-like interpretation on the features on the human face.

This work was done in 1999 at the University of California, Berkeley with a research team lead by Professor Yang Dan. Naturally, this brain reading was invasive by virtue of the fact that electrodes needed to be implanted on the brain.

Apart from cats, visual imagery has also been read from human brains. This work was done in 2011 by scientists at the University of California, Berkeley lead by Professor Jack Gallant. In this case non-invasive function magnetic resonance imaging (fMRI) techniques and computational modelling were used to read and interpret brain activity. Subjects watched video clips and the moving images were read from their brains.

To extract this video information from the brains of experimental subjects they had to lay still inside a fMRI machine while watching two different sets of trailers from Hollywood movies. The fMRI machine was used to measure the blood flow through the visual cortex of the brain which is the part responsible for vision. The fMRI data was then broken down into three dimensional versions of pixels known as "voxels".

One of the researchers said "We built a model for each voxel that describes how shape and motion information in the movie is mapped into brain activity". As the video was being played to the subject the change in each voxel, corresponding to changes in brain activity in that region, was correlated with the video image being presented at the time.

A problem of using fMRI for this type of work is that the blood flow which fMRI measures changes much more slowly than the electrical neural signals. This problem was overcome by the development of a two stage model that separately describes the neural signals and blood flow.

However, the scientists who did this work were careful to point out at the time that the technology to read people's thoughts is many decades away. A video of the experiment can be seen at http://youtu.be/nsjDnYxJ0bo *"Movie reconstruction from human brain activity"*.

Reading the subject matter of dreams

Japanese researchers Yukiyasu Kamitani and colleagues at the Advanced Telecommunications Research Institute International in Kyoto, Japan have been working on reading the subject matter of people's dreams.

In work published in 2013 they showed that they could tell what a person was dreaming about. The research involved asking volunteers to have a mid-afternoon nap in a fMRI machine and when they had reached the earliest stages of sleep (stage 1 or 2) they were woken and asked to give a verbal report of what they were dreaming about. This was repeated at least 200 times for each subject.

Next, these verbal dream reports were analysed by researchers who reduced them to key words and concepts. Researchers next went online to build a vast visual database of images that mostly closely corresponded to the subject matter of the verbal reports provided by the dreamers.

Researchers then did further fMRI scans on the dreamers while they were awake and asked them to watch the images that had been collected that corresponded to the subject matter reported from their 200 plus dream sessions. This enabled brain activity patterns to be read from that individual that corresponded to the visual imagery they were watching. These activity patterns were used to train a decoder computer to correlate patterns of brain activity with certain types of visual imagery.

After the decoder was trained it was possible to enter measured brain activity and it could then correlate that with the visual imagery now known to produce this pattern and thus the subject matter of the dream could be predicted.

The predictive capacity of the system was quite coarse. For example, it could tell if someone was dreaming of driving in a car but not what type of car. Also, the decoder has to be trained individually for each person. It cannot be used to read dream subject matter without individualised training.

See YouTube video http://youtu.be/inaH_i_TjV4 *"Dream decoding from human brain"*.

Transmitting thoughts from one person to another

In early 2014, a team lead by Alvaro Pascual-Leone, Director of the at the Berenson-Allen Center for Noninvasive Brain Stimulation at Beth Israel Deaconess Medical Center (BIDMC) and Professor of Neurology at Harvard Medical School in Boston succeeded in reading a thought from one person and transmitting it to another person 8,000km away via the Internet.

Together with researchers in France and Spain, the thoughts of a person in India were transmitted to a person in France. The words transmitted were the greetings "hola" and "ciao". In reality it was not words that were transmitted but a binary code. The sender evoked imagery of using either their hands or feet. The brainwaves of the sender in India were read by an EEG and it was determined if they were imagining using either their hands or feet.

Hands corresponded to a "0" and feet to a "1". The chosen number was transmitted over the Internet to France and the receiver's brain was stimulated via the process of transcranial magnetic stimulation (TMS). The TMS stimulation was interpreted as a flash of light (phosphene) for a 1 and

no flash for a 0 and thus the simple message was decoded.

Connecting two rat brains together

The brains of two rats were electronically linked such that what one rat did was duplicated by another rat at a distant site. A team lead by Miguel Nicolelis of Duke University in North Carolina and collaborators in Brazil published this work in early 2013.

One rat called the "encoder" learned various tasks and signals from a cortical micro-electrode array implanted in it were monitored. The electrical signals from the encoder rat's brain were then transmitted to the same area of a "decoder" rat's brain.

The encoder's electrode arrays consisted of 32 electrodes connected to the rat's primary motor cortex of the brain which is responsible for movement. The decoder rats had 4 to 6 micro-stimulation electrodes implanted in the same area.

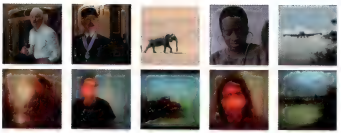
When the decoder rat received signals from the encoder rat's brain it interpreted the action meant by those signals and performed the same task (pressing the same lever) as the encoder rat. Even when the decoder rat was untrained and unfamiliar with the task the decoder rats would press the correct lever around two thirds of the time which while not perfect is still a remarkable result.

The encoder rat was located in Brazil while the decoder rat was located in the USA. A video of the experiment can be seen at **http://youtu.be/w_qbkYDlhDY** *"Brain-to-brain interface transmits brain activity directly from one rat to another"*

Human-to-animal control

Transmitting a thought from one person to another is impressive but so too is transmitting a command from a person to animal. Seung-Schik Yoo of Harvard Medical School in Boston lead the team. A person was connected to an EEG machine and used the technique of steady state visual evoked potential (SSVEP) to trigger a signal for a rat to move its tail. The rat's brain was stimulated in the area that controls tail movement by the technique of focused ultrasound (FUS) and the rat moved its tail.

The experiment can be seen at **https://www.youtube.com/watch?v=VaJjHgyHnEc** *"Human moves rat's tail with thoughts alone"*. See also **http://youtu.be/TpFdM_e76Fw** *"LEGO goes with the brain: A robot remotely controlled with steady-state visual evoked potentials"*,



Still images taken from video showing the presented image (top) and the corresonding image read from a human brain using functional magnetic resonance imaging (fMRI). (From http://spectrum.ieee.org/geek-life/tools-toys/this-is-your-brain-on-fmri)

(sic) in which a robot is controlled by a person using SS-VEP techniques.

Human-to-human control

Researchers at the University of Washington have enabled one person to control motion in another person. The first person thought of an action to move their hand to press a button but did not actually move their hand. The electrical activity in the brain associated with this intention was recorded with an EEG headset and transmitted via the Internet.

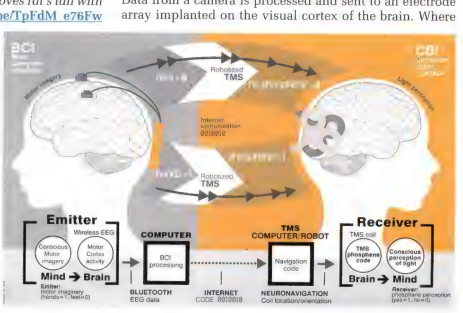
The brain of a receiving subject was stimulated via the process of transcranial magnetic stimulation (TMS) which induced an electrical signal in the brain of the subject over an area responsible for hand movement causing them to physically move their hand to press a button.

This may sound scary in some senses but it is important to note that this work is currently at a very basic level and there is no indication that mass mind control or robot-like zombie people will be walking our streets any time soon.

See **http://youtu.be/rNRDc714W5I** *"Direct Brain-to-Brain Communication in Humans: A Pilot Study"*.

Human vision & movement

An obvious application for interfacing the brain is to provide vision for blind people. Retinal implants ("bionic eyes") are one such approach but if this is not suitable the vision areas of the brain can be stimulated directly. Data from a camera is processed and sent to an electrode array implanted on the visual cortex of the brain. Where



Scheme by which a thought was transmitted from one person to another over the Internet. From http://abcnews.go.com/Technology/scientists-transmit-thoughts-brain/story?id=25319813

this has been done the subjects have gained some limited level of functionality to enable them to do basic tasks and even driving a car slowly in a car park was demonstrated in one instance.

BCIs have been used to help disabled people control computer cursors for communication, wheelchairs and robotic arms to help them with household tasks. See YouTube videos http://youtu.be/mJQ0HqThU4c *"Two-Dimensional Cursor Control Using EEG"*, http://youtu.be/qQ7AJnVKc_g *"Mind Typing and PC Control with Brain-Computer Interface (BCI)"*, http://youtu.be/gvR0kHm9fwo *"BCI driving a wheelchair"* and http://youtu.be/76lIQtE8oDY *"One Giant Bite: Woman with Quadriplegia Feeds Herself Chocolate Using Mind-Controlled Robot Arm"*.

Neurogaming

Neurogaming is a new computer gaming modality where characters and games are controlled by BCI technology as well as other sensors such as heart rate monitors, eye-trackers and sensors to detect muscle movement. Such technology can also be used for virtual reality training for different professionals and has also been suggested for the treatment of various disorders such as PTSD, ADHD and other behavioural and cognitive disorders.

Future uses

Anything that requires human input for control is open to the possibility of direct control via a brain-computer interface. For precise and high levels of control it may be necessary to have implanted electrode arrays since at the moment scalp EEG readings are fairly coarse in nature although if training with EEG headsets started at a young age, better results might be achievable.

The military also have some interest in controlling fighter jets and other machines with the mind (whether the pilot is in the cockpit or a remote operator). *Firefox* (1982) was a science fiction movie which features an aircraft with a mind-controlled weapons system but the English-speaking pilot tasked to retrieve the plane could not get it to work until he realised he had to think in Russian, not English.

Brain-controlled toys

A number of toys have been produced or are under development which are controlled by the brain. One such toy is a radio-controlled helicopter called the Puzzlebox Orbit which us controlled via a NeuroSky EEG headset (see below).

Instructions for a do-it yourself conversion of a cheap radio controlled helicopter to mind control using consumer EEG headsets is described at http://www.instructables.com/id/Brain-Controlled-RC-Helicopter/

Note that on that web page on the right hand column you will see links to other brain control DIY projects.

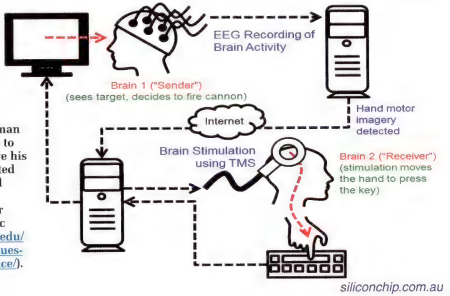
Consumer EEG headsets

Interfacing the brain is not just restricted to laboratories. There are a large number of consumer grade EEG headsets available for the purpose of brain computer interfacing. They are all capable of measuring a number of mental states and some can measure facial muscle movement and eye movement as well. A full description of these devices is not possible here but you may wish to research them yourselves. These devices have between 1 and 14 electrodes. Some of these headsets are also appropriate for professional use and research.

The devices include: Emotiv EPOC, Emotiv Insight, HiBrain, iFocusBand, Mindball, Mindflex, MindSet, MindWave, Muse, MyndPlay BrainB, Neural Impulse Actuator (discontinued and detected muscle movement only), NeuroSky, OpenBCI (this is an open hardware project, see box), Star Wars Force Trainer (discontinued), Xwave headset (discontinued) and Xwave Sonic (discontinued).

Of particular interest is that Emotiv Systems is a Sydney-based company with international offices, founded by former Young Australian of the Year, Tan Le. For an overview of some features of one of the Emotiv headset models see the YouTube video at http://youtu.be/bposG6XHXvU *"Emotiv's New Neuro-Headset"*.

A lot of open-source software has been developed to support the output of some of these and other EEG devices. An example is OpenViBE, which is a general purpose and highly capable software platform for real-time acquisition, processing and classification of brain waves for all aspects of brain-computer interfaces including biofeedback, robot-interfacing, diagnosis, biofeedback and game control. OpenViBE can be used by anyone even if they are not familiar with programming. Several open-source Matlab toolboxes have also been developed for interpreting data



Scheme for brain to brain interface with human subjects. A sender imagines hand movement to press a fire button but does not actually move his hand. The intent to press the button is detected via EEG signals and the signal is transmitted via the Internet. The person receiving the signal is stimulated to press a button as their brain is stimulated via transcranial magnetic stimulation (TMS). (From www.washington.edu/news/2013/08/27/researcher-controls-colleagues-motions-in-1st-human-brain-to-brain-interface/).

from various EEG devices.

With any EEG device, receiving unwanted electrical noise from muscles can be a problem with these devices so a special effort has to be made to avoid unwanted movement, especially of the facial area, when using these devices.

Silicon Chip readers may be interested in experimenting with some of these devices and software tools.

Many of these devices can be connected to smart phones for purposes such as meditation, biofeedback or playing games (neurogaming) or other possible purposes such as assisting the disabled to communicate, for research, software usability testing and so-called neuromarketing where a person's reaction to advertising material is monitored.

BCI2000

In addition to the open source software mentioned above to analyse EEG signals, BCI2000 (**www.schalklab.org/research/bci2000**) is an open-source suite of software for all aspects of brain-computer interface research and can be used for data acquisition, stimulus of neurons and brain monitoring applications.

It is free for non-profit and educational use and supports numerous types of instrumentation and runs on Windows, OS X and Linux.

It has been under development since 2000 by the Brain-Computer Interface R&D Program at the Wadsworth Center of the New York State Department of Health in Albany, New York with substantial contributions from various other groups.

BCI2000 is designed to easily interface with various equipment and software in real time via a network-based interface so that, for example, a robot arm running its own software could be made to be easily controlled by neural signals processed by BCI2000. In addition, Matlab scripts can be executed within BCI2000.

BCI2000 has an additional benefit that all data is stored in a standardised format along with the system configuration and event markers so that it can easily be shared with other researchers.

To see an example of BCI2000 in use see **http://youtu.be/suKTlrzaU9g** *"Playing the Game 'Pong' with EEG"*. Here a 32-channel EEG is acquired and analysed from each of two subjects to extract control signals which move the electronic game paddles.

Ethical issues

As with any new technology certain ethical issues need to be considered, especially with intrusive brain interfaces such as cortical electrode arrays. While few would question the need for such intrusive interfaces in life-critical applications such as controlling a wheelchair or robot arm, one might question the appropriateness of such an interface for a non-critical application such as connecting to the Internet.

On the other hand many would argue that a person is entitled to do as they will with their own body as long as that person pays for it.

Other issues relate to the reversibility or otherwise of intrusive BCI interface procedures. Most implants, no matter what type, leave some sort of permanent impact on the body and may not be removable without doing damage. What issues arise if better models of interface are developed and old ones need to be removed?

Cyborg Roaches!

We make no judgement on the ethics of doing this but some people have built their own remote controlled living cockroaches with parts from a kit as featured in this video. **http://youtu.be/V2zNOP6RqRk** *"Amazing! Real Creating a Cyborg Cockroach (Bugs Robot)"*.

It is not known whether this would work with typical Australian cockroaches.

It is not a joke! Note that the developer does consider ethical issues and addresses them on their web page at **https://backyardbrains.com/products/roboroach**

Alternative therapies also need to be considered. For example, with advances in stem cell research it is conceivable that in the near term future spinal cords could be repaired and the necessity to have an electrode implant for brain control of a wheelchair might become unnecessary (but people already in receipt of such implants might be able to re-purpose them).

Conclusion

Brain-computer interfacing has an exciting future and it is likely that the first major uses will be to assist disabled people to communicate and move.

Neurogaming, like much computer gaming is likely to have many spin-offs such as virtual reality and treatment of various disorders. Later developments might include control of cars, aircraft and many other machines as well.

Some people may consider the technology "inhuman" and may choose to preserve what they see as their humanity. Controlling animals with BCI may bring many benefits such as in search and rescue but may also raise ethical challenges.

Neuroplasticity ensures that most people should be able to learn to use BCI and most likely do useful things with non-intrusive BCI such as EEG headsets. Other ethical challenges are raised due to appropriateness of the technology for certain uses and cost.

In the medium to long term future the rights of people not to have their mind read (should that prove to be possible) need to be seriously considered. BCI is potentially very useful for the disabled but biological cures using stem cells for conditions such as a severed spinal cord may be better and not far off.

The nightmare scenarios from science fiction seem a long way off, if they happen at all. SC

YouTube videos of interest:

Visual Image Reconstruction from Human Brain: http://youtu.be/daY7uOoeftA

A Remote Controlled Rat: http://youtu.be/G-jTkqHSWIg

Cyborg insects: http://youtu.be/dSCLBG9KeX4

Computer records animal vision in Laboratory – UC Berkeley: http://youtu.be/pjvY-UtyDZw

The Micromite Mk.2

More memory, more functions & much faster than before!

Introduced in the May 2014 issue of SILICON CHIP, the Micromite is a small 28-pin chip running a powerful BASIC interpreter. Now we introduce the Micromite Mk.2 with more memory, higher speed and a host of other improvements. It's all due to the relentless march of semiconductor technology.

By Geoff Graham

THE SEMICONDUCTOR industry does move fast. Just after the introduction of the Micromite back in May 2014, the manufacturer of the PIC32MX150F128 microcontroller used in the device surprised us with a new version of the chip. Designated the PIC32MX170F256, it has the same capabilities as the original but has double the amount of RAM and flash memory. Even better, it only costs 40 cents more.

We had gone to a lot of effort to squeeze the MMBasic interpreter into the original chip. However, as soon as we saw the new chip, we started thinking of implementing some of the features that were missed out in the original version. The result is the Micromite Mk2. It does everything the original Micromite did but it does it much faster, with a lot more memory and a lot more features.

The original Micromite is still fine for everyday jobs; it's just that it now has a newer and faster cousin.

The Micromite

Just in case you missed the May 2014 issue, the Micromite is a PIC32MX150F128 microcontroller programmed with our BASIC interpreter called *MMBasic*. This microcontroller comes in two package styles: (1) a 28-pin plastic dual-in-line (DIL) package which can be plugged into a breadboard or IC socket; and (2) a 44-pin surface mount (SMD) package.

The 28-pin Micromite has 19 I/O pins which can be configured by the BASIC program to be digital inputs or outputs, analog inputs, frequency measurement inputs and more. The 44-pin chip has 33 I/O pins with the same characteristics.

The BASIC interpreter running on the Micromite is a high-level implementation of the language. It supports floating point and strings, long variable names, arrays with multiple dimensions, user defined subroutines/functions and a host of other advanced programming features.

Programs are stored in the chip's internal flash memory and can be edited on the chip using the inbuilt full-screen editor and a serial link. A program can be configured to run immediately on power-up so that the Micromite acts as a pre-programmed custom chip and the user need not know anything about what's running inside.

Perhaps the most powerful feature of the Micromite is the range of communications protocols that it supports. These include I^2C, asynchronous serial, RS232, IEEE 485, SPI and 1-Wire. Using these, your program can communicate with other chips and sensors and can send data to test equipment.

The Micromite Mk.2 is just a Microchip PIC32MX170F256 microcontroller programmed with Version 4.6 of our MMBasic interpreter. You can buy the microcontroller in both 28-pin and 44-pin versions and once programmed it turns into an easy to use controller that you can employ for a host of tasks, eg, servo control, infrared remote control, distance sensors, temperature sensors and much more.

The new chip

As stated, the Micromite Mk.2 uses the new PIC32MX170F256 series. For people who struggle to decode these

part numbers, "PIC32" refers to the 32-bit family of Microchip processors, "MX170" is the chip's part number and "F256" refers to the amount of flash memory in the chip (256K bytes in this case).

The MX170 comes in a number of variations with different packages, pin numbers and maximum speeds. Table 1 lists the versions suitable for the Micromite Mk.2 and their characteristics. The recommended part number is the PIC32MX170F256B-50I/SP. This has a top speed of 50MHz and is in a plastic DIL package with 28 pins.

If you purchase one of these from Microchip, it will cost you around $US4 (plus freight). You then need a programmer such as a PICKit3 to load the MMBasic firmware and turn it into a Micromite Mk2. Alternatively, if you only need a few chips, a more convenient option is to purchase the chip fully-programmed from the Silicon Chip OnlineShop for $15.00 plus postage.

More memory & much faster

One of the great features of the Micromite Mk2 is that the free space for your BASIC programs has been increased to 58KB and the amount of free RAM is now 52KB. This is a huge increase on the original Micromite which had just 20KB and 22KB respectively.

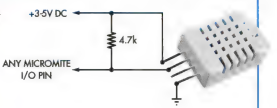
Previously, you could run quite large programs. Now you can run truly enormous programs with plenty of comments and other components that consume the program space. In addition, the extra RAM allows your programs to build large arrays for manipulating numbers and large buffers for moving data around.

Another feature of the Micromite Mk2 is that it is much faster than the previous version. The chip used in the original Micromite had a limited amount of flash memory, so when we squeezed the MMBasic interpreter into this chip, we had to optimise it to conserve space. And that slowed down the interpreter.

With double the amount of flash memory in the Micromite Mk2, we have the luxury of optimising the interpreter for speed. So now programs on the Micromite Mk2 will run about 40% faster than on the previous Micromite running at the same clock speed.

In fact, the Micromite Mk2 has more memory and runs faster than the popular Maximite and Colour Maximite computers described in the March 2011 and September 2012 issues of Silicon Chip.

Fig.1: the DHT-22 is a combined temperature & humidity sensor that is supported by MMBasic in the Micromite Mk2. Using just one command you can get both the temperature and humidity with no complicated programming required. Note that the DHT-22 is also known as the RHT03 or AM2302.



Big numbers

The original Micromite used floating point numbers (often abbreviated to "float") for all arithmetic. Floating point is good because it allows you to have numbers with a decimal point such as "12.4". However, the problem with floating point numbers is that they only store an approximation of the number when the number has more than six or seven significant digits.

Despite this issue, floating point is still the best for general purpose computing. It is rare that you need more than six digits of accuracy in everyday life and operations like division always do what you expect when you are using floating point. On the other hand, when you are working in an embedded controller environment, you often need more precision than floating point numbers can provide.

Because of this, we have given the Micromite Mk.2 the ability to store and manipulate numbers as 64-bit signed integers. These can be used to accurately count and manipulate numbers up to nine million million million (or ±9,223,372,036,854,775,807 to be precise), which is a very large number indeed.

The downside of an integer is that it cannot store fractions (ie, numbers after the decimal point). Any calculation that produces a fractional result will be rounded up or down to the nearest whole number when assigned to an integer.

New Features In The Micromite Mk.2

- The same hex file works with both 28-pin and 44-pin chips.
- The amount of free memory for programs is increased by 300%.
- Programs will run about 40% faster at the same CPU speed.
- 64-bit integers can be used to store and manipulate numbers as large as 19 digits.
- 64-bit integer arithmetic is about 25% faster than floating point.
- A full SELECT...CASE decision structure has been implemented.
- Compiled C or assembler programs can be embedded in the BASIC program.
- The temperature and humidity can be read from a DHT22 sensor.
- The frequency of the internal clock can be trimmed for better timekeeping.
- The >> and << operators can shift bits in a number to the right or left.
- The processor can be put to sleep for a specified number of seconds.
- The gate time used when making frequency measurements can be specified.
- Internal pull-up or pull-down resistor can be enabled for any input pin.
- Voltage measurements can be corrected for variations in the supply voltage.
- The console can be used with RS232 signals without a converter.
- The TIMER function will now count up for over 200 million years.
- The SPI function can now send/receive data in 32-bit blocks (in addition to eight and 16 bits).
- Additional features to prevent common programming errors.
- The manual has been updated and it includes a full bookmark listing.

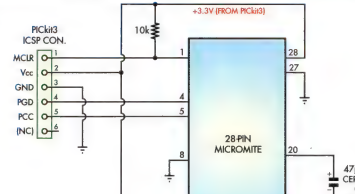


Fig.2: here's how to connect a blank 28-pin chip to a PICkit3 programmer to load the MMBasic firmware for the Micromite Mk2. Once connected, you use MPLAB IPE (free from Microchip) to program the device. Note that the 47µF capacitor is critical and must be a tantalum or multilayer ceramic type.

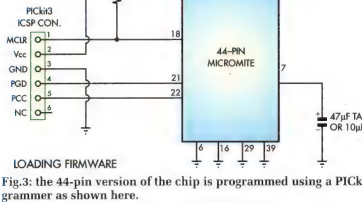


Fig.3: the 44-pin version of the chip is programmed using a PICkit3 programmer as shown here.

An illustration of where 64-bit integers come in handy is when you are dealing with latitude and longitude. For example, you might be planning a project which needs to capture these two numbers from a GPS module and use them to calculate the distance between two points.

The problem comes about because latitude and longitude need to be stored with more than six digits of accuracy. For instance, the longitude of Sydney is 151.2094° and a floating point variable will only store that number as an approximation. This is a significant issue because even a slight variance in the stored number could represent an error amounting to several kilometres.

However, you could store the latitude and longitude in hundredths of a second and use 64-bit integers to handle the number (Sydney's latitude in hundredths of a second is 54,435,384). Because integers retain the full precision of the number, the location will be accurate to better than one metre.

There are many other cases where large and precise numbers are required; eg, when working with frequency synthesisers.

Calculations involving integers are also faster than floating point calculations (by about 25%) and there is nothing stopping you from using them exclusively in your programs if you need a bit more speed. The only drawback is that integers cannot store fractions, only whole numbers. For many programs though, that is not an issue.

In MMBasic, 64-bit integers are specified by adding the percent symbol (%) as a suffix to a variable name. For example:

Count% = Count% + 1

Because this expression uses 64-bit integers, it will be able to count up to a number with 19 digits with perfect accuracy. Even doing nothing else, a Micromite Mk2 running at full speed would take millions of years of counting to reach this limit.

Mixed arithmetic

With the introduction of two types of numbers (floating point and integers), you might be wondering how MMBasic handles the two when they are mixed in a calculation. Well, in general, this is done automatically and is transparent to the programmer.

For example, if you assign a floating point to an integer, MMBasic will automatically convert it to an integer, including rounding the fractional component to the nearest integer. The opposite action will convert an integer to a float.

Because floating point numbers can handle a wider range of numbers, the interpreter will automatically promote an integer to a float when the two are mixed in an expression. For example, in the following program fragment, the value of B% will be automatically converted to floating point with the result that 123.45 will be stored in Nbr:

A = 23.34
B% = 100
Nbr = A + B%

If all numbers in an expression are integers, then they will be left as integers and an integer will be returned. The only exception to this is division using the normal divide operator (/). In this case, both sides of the expression will be promoted to a floating point number and a floating point number will be returned.

For integer division, you should use the integer divide operator (\). It will leave both sides of the expression as integers (or convert them if they are floats) and return an integer while truncating any fractional part.

If you use constant numbers (eg, 23.45, 100, etc) in an expression, they will be treated as a floating point number if they contain a decimal point and an integer if they do not.

Functions in MMBasic return integers or floating point depending on their characteristics. For example, the function to get the length of a string (LEN) will return an integer while

TAN() will return a floating point. As another example, PIN() will return a float if it is measuring voltage but an integer if it is counting the pulses in an input signal.

CFunctions

Another new feature in the Micromite Mk2 is the ability to define program modules written in C or MIPS assembler. These modules can be easily called by your BASIC program and can be used to implement functions that cannot be implemented in BASIC.

Typically, you use CFunctions to access special features of the PIC32 chip or where speed of execution is required. As an example, the firmware zip file for the Micromite Mk2 (available on the SILICON CHIP website) includes a CFunction that will add up to eight additional serial I/O ports. This isn't something that you could do in BASIC alone, as the interpreter is not fast enough for this type of bit manipulation operation.

However, by adding the code for the CFunction to your BASIC program, you can have the best of both worlds – the easy-to-program BASIC language and the high-speed ability of a function written in C.

A few caveats are in order here. Writing in the C language is nowhere near as easy as writing in BASIC and the environment of the CFunction is limited. For example, you cannot interact with MMBasic (except in limited ways) or call standard library functions. However, CFunctions are handy for small functions that cannot be accomplished using BASIC.

Example CFunctions

The zip file containing the Micromite Mk.2 firmware includes a number of example CFunctions. These include sending serial data, receiving serial data, discovering the chip type that the program is running on (28-pin or 44-pin) and discovering the current clock speed.

By using pre-compiled functions like these, you will be able to add functionality to your programs without having to know anything about the internals of the CFunction. Hopefully, other people will write more CFunctions and expand the library in the future.

If you do want to delve into writing CFunctions yourself, the Micromite Mk.2 zip file includes a link to a 74-page tutorial which goes into all the details.

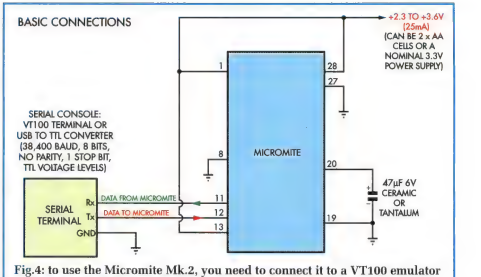


Fig.4: to use the Micromite Mk.2, you need to connect it to a VT100 emulator such as the ASCII Video Terminal described in SILICON CHIP in July 2014. Alternatively, you can connect it to a PC via a USB-Serial bridge. You can then use programs such as Tera Term or MMEdit to create programs and download them to the Micromite (see text). As before, the 47µF capacitor is critical and must be a tantalum or multilayer ceramic type.

Select...Case

One often requested feature in MMBasic is the SELECT...CASE statement. Given the expanded flash memory capacity of the new chip, we have now been able to add this.

This is generally used as a replacement for the IF...THEN...ELSEIF construct. The SELECT...CASE statement is much easier to use and makes the intentions of the program much more obvious to the casual reader (which might be you in a few years time). The structure is:

```
SELECT CASE value
  CASE testexp [[, testexp] ...]
    <statements>
    <statements>
  CASE ELSE
    <statements>
    <statements>
END SELECT
```

The "value" is the value to be tested against each following *CASE* statement, while "testexp" can be a wide range of test expressions. For example, you can say 5 to 8 which will match the numbers 5, 6, 7 and 8. You can say >5 which will match any value greater than 5. There are many more tests that you can make and they are detailed in the user manual.

Reduced programming errors

While the BASIC programming language has the reputation for being easy to learn it also has a darker reputation for creating some difficult to debug programs. The new Micromite Mk2 has a number of additional features to help eliminate many of the more common programming errors and make it easier to debug the final program.

For some time, MMBasic has had structured programming elements like multi-line IF...THEN constructs and subroutines/functions. These have mostly eliminated the need to use the GOTO command which has the

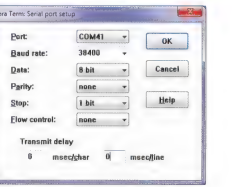


Fig.5: the terminal emulator that you use to connect to the Micromite Module (via USB) should be set to 38,400 baud, eight bits data, no parity and one stop bit. This screen grab shows what the set-up dialog in Tera Term should look like with the correct values entered. Note that your port number will almost certainly be different to that shown because it will change with the physical USB port.

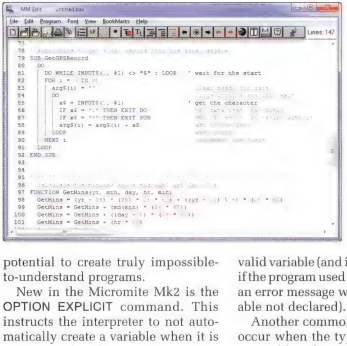


Fig.6: MMEDIT was written by Jim Hiley and can be installed on a Windows or Linux PC. It allows you to edit your program on the PC and then, with a single mouse click, transfer it to the Micromite for testing.

potential to create truly impossible-to-understand programs.

New in the Micromite Mk2 is the OPTION EXPLICIT command. This instructs the interpreter to not automatically create a variable when it is encountered in the program.

Previously, when MMBasic found an expression like nbr = 1234, it would automatically create the variable nbr and then assign the number 1234 to it.

This is fine for quick and dirty programs but in a larger program, disaster can strike if the variable was misspelt.

For example, if the programmer accidentally misspelt the above variable as nmbr, the interpreter would automatically (and silently) create it with the value of zero. The programmer, who expected it to contain 1234, might miss this subtle change in testing, with the result that the program contained a potentially serious flaw.

Now the programmer can specify OPTION EXPLICIT which will throw an error when the new variable is encountered without being explicitly declared beforehand. The way you do this is with the DIM command. For example, at the beginning of the program you can state:

DIM AS INTEGER nbr

This tells the interpreter that nbr is a valid variable (and is an integer). Then, if the program used a reference to nmbr, an error message will be shown (variable not declared).

Another common class of bugs can occur when the type suffix is left off a variable. The type suffix indicates the type of variable – for example "$" indicates a string and so data$ would be a string. If the suffix was accidentally left off during program entry, the type of variable would then be a number, which is significantly different from that which the programmer had intended.

To prevent this type of error, the programmer can specify OPTION DEFAULT NONE which tells MMBasic that variables must have a type suffix or the type must be explicitly specified in the DIM command. In fact, placing both OPTION EXPLICIT and OPTION DEFAULT NONE at the start of your program is good programming practice and will draw attention to a wide range of common programming errors.

The OPTION DEFAULT command also allows you to specify the default type for a variable without a suffix. This can be convenient for a short program where you are only using integers (for example); you can then specify OPTION DEFAULT INTEGER and gain the speed benefit of integers with the shortcut of not having to specify a suffix.

It does fly in the face of what we were talking about above but it is acceptable for short programs that only use the one type of variable.

Constants

Another source of bugs is the use of literal numbers as constants in a program. Let's say that you are building a single-cell battery charger using the Micromite and you need to detect when the cut-off voltage has been reached. Your program might use something like this:

IF PIN(15) > 1.8 THEN ...

But what does pin 15 connect to and what does 1.8 represent? In a year or two when you need to modify the program, you will have probably forgotten.

You could always use a variable called "MaxV" and set it to the threshold voltage but that runs the danger of being accidentally changed somewhere else in the program. A much better option is to use the new CONST command. For example:

CONST BattV = 15, MaxV = 1.8

Then the above program line would read:

IF PIN(BattV) > MaxV THEN . . .

which is much more understandable to the casual reader.

Another benefit of constants defined by the CONST command is that you can use them through your program and if you need to change the value of one particular constant you can do it easily in the one place.

DHT22 sensor

The DHT22 sensor is a module that will measure temperature and humidity and can be purchased for less than $5 on eBay. Support for the DHT22 has been added to the Micromite Mk2 and it provides a convenient method of measuring these two key weather parameters.

Connecting the DHT22 is straightforward (see Fig.1) and getting the temperature and humidity into your BASIC program is just as easy. The command is:

DHT22 pin, tVar, hVar

where pin is the I/O pin used to connect to the DHT22 and tVar and hVar are floating point variables. After this command has been run, tVar and hVar will be updated with the measured temperature and humidity, with a resolution of one decimal place.

Another useful addition to the Micromite Mk2 is the ability to specify an internal pull-up or pull-down resistor on any input. Using a pull-up, for instance, allows you to connect a switch directly to an input pin. When the switch is open, the pull-up resistor will keep the input high but when the switch is closed, the input will be pulled low.

Overall, there have been almost 50

Where To Get The Micromite Mk2

A pre-programmed Micromite Mk2 chip (28-pin version) is available for $15 plus p&p from the SILICON CHIP Online Shop (includes the 47µF capacitor). MMBasic and a User Manual are also available on the SILICON CHIP website (free of charge).

new features and enhancements in the Micromite Mk2 and a summary of these is listed in the panel at the start of this article. For the full list, download the updated firmware from the SILICON CHIP website and refer to the detailed change log which is included in the zip file.

The zip file also includes the Micromite Mk2 User Manual which goes into far more detail than we can provide here. It runs to almost 80 pages and includes a detailed description of each command and function. About half the manual is devoted to tutorials and explanations so it also provides an easy learning path for beginners to the Micromite and programming using BASIC.

Programming the chip

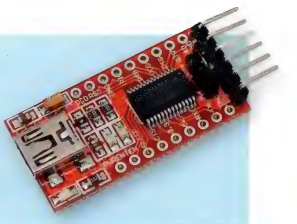
As we said earlier, the easy way to get going with the Micromite Mk2 is to purchase the chip fully programmed with the MMBasic language from the SILICON CHIP website – **www.siliconchip.com.au** There are also some web based companies such as **micromite.org** and **www.circuitgizmos.com** who also supply the chip fully programmed.

As previously stated, another option is to purchase a blank chip directly from Microchip (**www.microchipdirect.com**) or their distributors (element14, RS Components etc) and program it yourself.

To program the chip you need the Micromite Mk2 firmware (download it from the SILICON CHIP website) and a PIC32 programmer such as the PICkit3 from Microchip. There are also many PICkit3 clones available on eBay and other sites for as cheap as US$30 and they seem to do the job just as well as the genuine product.

In order to use the PICkit3, you need to download and install MPLAB X from Microchip. This includes a full development environment for Microchip products but the part of interest is the programmer called MPLAB X IPE (IPE stands for Integrated Programming Environment). This is usually installed as an icon on your desktop (in Windows) and double-clicking on it will put you into the programmer.

Figs.2 & 3 show how the PICkit3 is connected to the chip. The 47µF capacitor is critical and should be a tantalum or multilayer ceramic type with an ESR (Equivalent Series Resistance) of less than 1Ω. Do not use an electrolytic as the microcontroller may intermittently restart without warning.



You can use a USB-to-serial bridge like the one shown here to connect the Micromite Mk.2 to a USB port on a PC. Once connected, you can use Tera Term or MMEdit to write programs for the Micromite and download them via this device.

Table 1: Micromite Mk2 Microcontrollers

CPU	Package & Speed
PIC32MX170F256B-50I/SP	28-pin DIL package. Guaranteed to run at 48MHz
PIC32MX170F256B-50I/SO	28-pin SOIC package. Guaranteed to run at 48MHz
PIC32MX170F256D-50I/PT	44-pin surface mount package. Guaranteed to run at 48MHz
PIC32MX170F256B-I/SP	28-pin DIL package. Guaranteed to run at 40MHz
PIC32MX170F256B-I/SO	28-pin SOIC package. Guaranteed to run at 40MHz
PIC32MX170F256D-I/PT	44-pin surface mount package. Guaranteed to run at 40MHz

This table lists the PIC microcontrollers that are suitable for use as a Micromite Mk.2. From our testing, the chips rated at 40MHz also ran at 48MHz (at room temperatures), so they are a viable choice if you cannot find the higher speed versions.

Using the Micromite Mk2

To write and test your BASIC programs on the Micromite Mk2, you first need to connect a VT100 terminal emulator to the console pins as shown in Fig.4. The emulator should have a TTL serial interface set at 38,400 baud (Fig.5).

You have two choices here: you can build the ASCII Video Terminal described in SILICON CHIP, July 2014 or you could use a USB-serial bridge as shown in the accompanying photo. A USB-serial bridge will convert the USB interface on a PC to a TTL level serial interface which can directly connect to the Micromite Mk2.

Note that the 47µF capacitor in Fig.4 is again critical (see the comments above related to this component).

If you are using a USB-serial bridge, you then need to run a terminal emulator on your PC and we recommend *Tera Term for Windows*. Another excellent choice is *MMEdit* written by SILICON CHIP reader Jim Healy and this can be downloaded from **www.c-com.com.au/MMedit.htm**

MMEdit contains a terminal emulator but it is also a powerful editor for MMBasic programs with features such as automatic formatting and colour-coded key words.

Using either *Tera Term* or *MMEdit*, you can develop and test your program and when you are finished, set the program to automatically run when the chip is powered up.

As a closing thought, consider that this little $4 chip has double the memory of the first personal computers which were programmed in BASIC (the Tandy TRS-80, Apple II, etc) and runs more than 50 times faster. That really is amazing.

Finally, for firmware updates and handy hints, check the author's website at **geoffg.net/micromite.html** SC

Issues Getting Dog-Eared? Keep your copies safe with our handy binders
Order online from www.siliconchip.com.au or fill in and mail the handy order form in this issue or ring (02) 9939 3295 and quote your credit card number.

By JIM ROWE and NICHOLAS VINEN

Isolating High Voltage Probe for Oscilloscopes

Here's a low-cost project which will allow you to use your oscilloscope to observe and measure AC mains and other high voltage waveforms safely. It has three switchable input voltage ranges, wide bandwidth and high voltage isolation between input and output.

Observing and measuring waveforms on the AC mains and in other high voltage circuitry is quite dangerous using a standard oscilloscope or with the usual passive probes.

And by "dangerous" we mean not only risking a possibly lethal electric shock to yourself, but also risking serious damage to your scope.

The danger arises mainly because the "earthy" side of all scope inputs is connected to the scope's internal frame, which is normally itself earthed via the mains cable.

And it needs to be earthed in this way, both for correct operation and for the safety of the operator – you. (An unearthed or "floating" scope is an accident/disaster waiting to happen, so never be tempted!)

So the earthy side of all scope inputs is connected back to mains earth, which clearly poses a problem when you want to make measurements in circuits where everything is operating at a high or significant voltage with respect to earth.

After all, where do you attach the "earth clip" of the scope probe?

For example, in a circuit connected directly to the 230VAC mains, you can't connect the earth clip to the Active line because this will at least blow one or more fuses and may even start a fire which destroys either the scope or various components in the circuit you want to make measurements in.

On the other hand you can't clip it to the Neutral line either, because this is often itself floating at a significant voltage with respect to earth.

Another problem arises because the input attenuator on each channel of most scopes can only be switched to a maximum setting of 5V/division, which corresponds to 50V/division when a 10:1 divider probe is being used.

Because there are usually only 10 vertical divisions on the display, this means that only waveforms of up to 500V p-p (peak-to-peak) can be displayed in their entirety.

Since the peak-to-peak amplitude of a 230VAC mains waveform is around 650V, this means that it simply can't be

The differential probe connects to the circuit being tested using a pair of standard multimeter probes, alligator clip leads or similar. The output signal is optically isolated and connects to the oscilloscope (or other test instrument) via a BNC lead. Three different attenuation factors are available; 10:1, 100:1 or 500:1, to suit the voltages being measured. The higher attenuation settings offer the best bandwidth, up to 1MHz.

displayed or measured properly.

Things are even worse when it comes to making measurements in circuits connected to the 3-phase 400VAC mains (415VAC with 240VAC mains).

It's true that 100:1 passive probes are available and these can be used to extend a scope's upper voltage limit to a nominal 500V/division or 5kV p-p.

But this type of probe does nothing to solve the main problem: where do you connect the probe's earth clip?

With most modern scopes having at least two input channels, there is usually only one way around this problem.

That's to use two 100:1 divider probes, one for each input channel, and remove the earth lead and clip from both probes.

Then the two channels are used in differential mode, to display and measure the voltage difference between the two tips. But unless the scope provides a differential (subtraction) mode (Ch1-Ch2 or Ch2-Ch1) display, it is not possible to achieve meaningful measurements.

Even if the scope does offer a differential mode, the resulting waveform may not be a true portrayal because the scope's common mode rejection may not be adequate when measuring high voltage circuits.

The best way of solving all of these problems is to use a special probe with full high voltage isolation built in, like the one we're describing in this article.

By the way, we know that this type of probe is available commercially. But the cheapest we could find was about $385 and they rapidly move up into the four-digit range.

We estimate that you should be able to build this new design for less than $100.

The new probe

Unlike other scope probes this one is not meant to be held in the hand but sits on the bench – with its insulated input leads running to the circuit under test and its output connected to one input channel of the scope via a BNC-to-BNC cable.

It's housed in a small ABS instrument box measuring 150mm long, 80mm wide and 30mm high.

All of the probe's circuitry, including the two 9V alkaline batteries it uses for power, is housed inside the box. The input leads plug into insulated "banana" sockets at one end of the box, while the BNC output connector emerges from the other end.

Specifications

An isolating high voltage probe for oscilloscopes, providing three voltage division ranges.

Division ranges:	÷500 (optionally, ÷200), ÷100, ÷10
Input resistance:	2.0MΩ || ~10pF
Linearity:	±0.05%
Bandwidth (see Fig.3):	10:1 range: DC to 500kHz (±0.5dB)
	100:1 range: DC to 1MHz (±1dB)
	500:1 range: DC to 900kHz (+0.2,-1dB)
Residual noise:	typically 1.4mV RMS, 2.5mV peak-to-peak
Input-output isolation resistance:	>10GΩ (500V)
Maximum working isolation voltage:	1.4kV peak (1kV RMS)
Isolation test voltage:	2.1kV peak (60 seconds)
Maximum transient I/O voltage:	8kV peak (10 seconds)
Power supply:	2 x 9V alkaline batteries
Typical operating current drain:	6.0mA from battery 1, 1.0mA from battery 2

On the top of the box are the two main controls: a small rocker switch to turn the probe's power on and off and a rotary switch used to select one of three voltage division ranges: ÷500, ÷100 and ÷10.

The important point to grasp is that inside the box, there's a high voltage "galvanic isolation barrier" between the input and output circuitry.

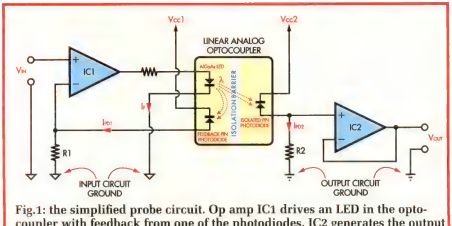


Fig.1: the simplified probe circuit. Op amp IC1 drives an LED in the opto-coupler with feedback from one of the photodiodes. IC2 generates the output signal from an identical, isolated photodiode. Note that $I_{PD1} \approx I_{PD2}$.

This allows the input leads to be connected to circuits operating at many hundreds of volts above (or below) earth, despite the fact that the probe's output is directly connected to the earthed input of a scope – and without causing any distress or damage.

In fact the isolation barrier inside the probe is able to withstand a peak "working" voltage of 1414V, or 2100V for up to one minute (60 second), or as high as 8000V peak for transients of less than 10 seconds in duration.

And if you're curious about the isolation resistance between the inputs and the output, this is more than 10GΩ (10 Gigaohms or 10,000MΩ).

How it works

The probe achieves this impressive performance because of a very special component: a high linearity analog optocoupler.

Understanding what this is and how it works is the key to understanding how the probe works as a whole, as we'll see shortly.

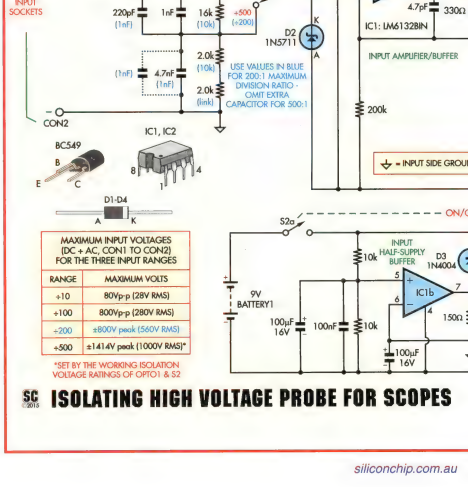
For the present, though, refer to Fig.1 which shows a basic linear analog isolation amplifier based on one of these devices.

The linear analog optocoupler is like a conventional digital optocoupler except that it has two PIN photodiodes sensing the infrared (IR) radiation emitted by the high performance AlGaAs LED. The two photodiodes are very closely matched in terms of their optical sensitivity and linearity.

The only difference between these "identical twin" photodiodes is that while one of them is located on the far side of the device's internal voltaic isolation barrier (like the output photodiode or transistor in a conventional optocoupler), the other is located back on the same side as the LED itself.

This allows the second photodiode to be used to provide linearising feedback, as a "proxy" for the isolated output photodiode.

The close matching of the two photodiodes means that when the LED is passing a current I_F and emitting radiation to both photodiodes, the current I_{PD1} passed by the feedback photodiode will have a value very close to that of the current I_{PD2} passed by the isolated output photodiode. By passing current I_{PD1} through resistor R1 to produce a voltage proportional to the LED current I_F, we can use the resulting voltage to provide input amplifier IC1 with negative feedback. This linearises



SC 2010 ISOLATING HIGH VOLTAGE PROBE FOR SCOPES

the operation of the input circuitry in converting input voltage V_{IN} into LED current I_F and hence the IR radiation passing over the isolation barrier.

Since the output photodiode's current I_{PD2} is virtually the same as I_{PD1}, we are then able to use resistor R2 to convert this current back into a voltage V_{OUT} which is also directly proportional to V_{IN}.

(IC2 is then used to buffer V_{OUT}, to ensure that any load connected to the output does not upset this linearity.)

In fact the resulting linear relationship between V_{OUT} and V_{IN} turns out to be very close to the ratio of R2 to R1, multiplied by the optocoupler's "transfer gain" K3 (where $K3 = I_{PD2}/I_{PD1}$). So

$$V_{OUT}/V_{IN} = K3.(R2/R1)$$

Because of the close matching between their twin photodiodes, most linear analog optocouplers have a transfer gain K3 of very close to unity (1.0); within a few percent.

So the overall gain of the basic linear isolation amplifier of Fig.1 simplifies down to:

$$A = V_{OUT} / V_{IN} = (R2/R1)$$

It also turns out that we can compensate for any small deviation of the optocoupler's K3 away from unity, simply by "tweaking" the value of R2.

So the overall gain of the isolation amplifier can be adjusted to be exactly unity, or whatever other figure we want it to be. So we achieve linear analog voltage gain while at the same time passing over a high voltage isolation barrier.

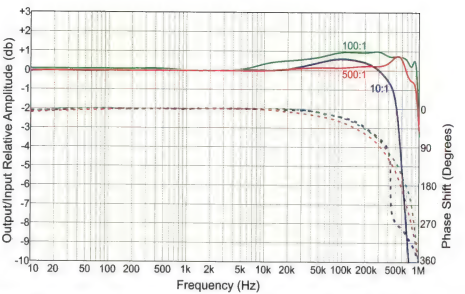


Fig.3: frequency response of the probe for each attenuation setting. The response is flattest at 500:1 but there is slightly more bandwidth at 100:1. The output/input signal phase shift for each setting is shown dashed, using the right y-axis.

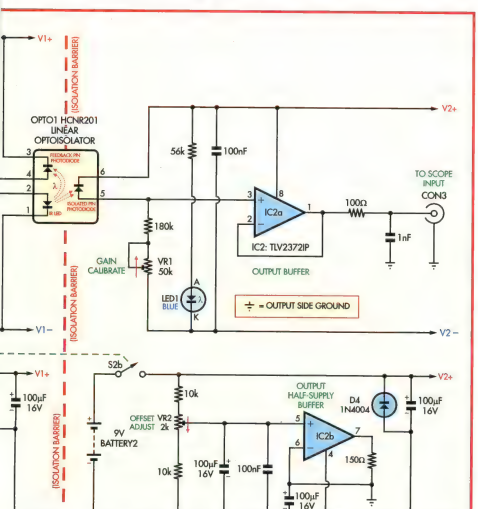


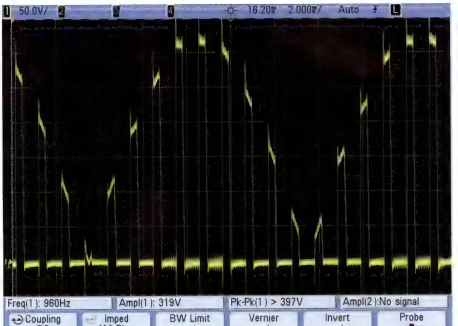
Fig.2: the complete probe circuit. The voltage being monitored is attenuated by a resistor/capacitor ladder and the selected tap connects to input pin 3 of IC1 via rotary switch S1. IC1b and IC2b provide half-supply rails to allow signals with bidirectional voltage swings to be probed.

Performance

We tested our prototype by measuring signals under a number of different circumstances. The 'litmus test' was connecting the probe across the motor of a drill plugged into our 230V/10A Speed Controller For Universal Motors (February-March 2014).

The result is shown in Scope1. This is gratifying as it gives a clear picture of the voltage across the load, despite the fact that it's floating at mains potential and with the fast rise/fall times displayed correctly. In fact, this result is almost identical to what we get with a commercial differential probe.

With its ~1MHz bandwidth, our probe can be used to view signals with a higher switching frequency than this. For example, it could be used to view



Scope1: the voltage across a drill powered by our 230V/10A Speed Controller for Universal Motors, showing a rectified mains waveform chopped at about 1kHz. The spikes are generated by the circuit; they are not measurement artefacts.

a floating Mosfet gate drive.

We did try it out connected across the output of our Induction Motor Speed Controller (April/May 2012) which has a much higher switching frequency, 36kHz.

While we were able to get a reasonable picture of the output waveform (Scope3 shows it "zoomed out"), the bandwidth of our probe is a little too low to show the very short pulses as a square wave. The voltage rise and fall times are simply too fast.

The full probe circuit

Now refer to the full circuit of Fig.2. The specific linear analog optocoupler device we're using is the HCNR201, made by US firm Avago Technologies. This has very impressive features:

- Low non-linearity: <0.01%
- Transfer gain: 1.00 ±5%
- Wide bandwidth: >1MHz
- Isolation: UL 5000V RMS for one minute
- Maximum working voltage: 1414V peak
- I/O test voltage: 2121V peak for 60s
- I/O transient over-voltage: 8000V for 10s

The IR LED of optocoupler OPTO1 is driven by op amp IC1a via transistor Q1. The transistor is used as an emitter follower to provide the required current drive for the optocoupler's LED, since IC1 is a low power device with low current drive capability.

The output photodiode of OPTO1 is connected to the non-inverting input (pin 3) of output amplifier IC2a, in exactly the same way as in Fig.1. Trimpot VR1 with its series 180kΩ resistor takes the place of R2 in Fig.1, with VR1 allowing the exact value of R2 to be adjusted to set the overall gain of the probe to unity.

At the probe's front-end circuitry, the 200kΩ resistor connected between pin 2 of IC1a and the input circuit's negative rail is the equivalent of feedback resistor R1 in Fig.1.

As you can see the anode of OPTO1's feedback photodiode (pin 4) also connects to the 200kΩ resistor, as in Fig.1.

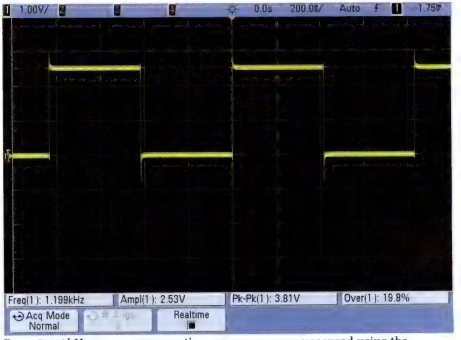
Note that the value of the 330Ω current-limiting resistor is important since its ratio with the 200kΩ resistor sets the current gain of the optocoupler and this affects the open-loop bandwidth of the surrounding circuit (ie, including IC1a). Increasing this resistor value reduces output overshoot but also reduces overall bandwidth.

The 4.7pF capacitor also has an effect on bandwidth (in combination with the 330Ω resistor) and is required for the circuit to be stable, due to the phase shift inherent in the DC feedback path via the opto-coupler.

Input voltage divider

The non-inverting input of IC1a (pin 3) is connected to input connectors CON1 and CON2 via a switched voltage divider, to provide the probe's three division ranges.

The switching is done by S1a, one pole of a 4-pole, 3-position rotary switch (the other poles are unused). The input divider is arranged so that it provides a fixed input resistance of



Scope2: a 1kHz scope compensation square wave as measured using the differential probe on its 10:1 setting. There are brief overshoot spikes at each edge but otherwise the shape is square with no ringing or distortion.

2MΩ on all three ranges.

A series of capacitors have been connected in parallel with the divider resistors. These are required for a number of reasons.

Firstly, they swamp the input capacitance of IC1a (exacerbated by the capacitance of D1 & D2), which would otherwise form a low-pass RC filter with the resistive divider network, seriously limiting the available bandwidth.

They also keep the AC impedance "seen" by IC1a low, minimising noise and RF/hum pick-up.

An extra 10pF capacitor placed across the top 620kΩ resistor in the divider provides some extra compensation to cancel out the input capacitance of IC1a.

Regarding the voltage ratings of these components, 90% of the voltage applied across inputs CON1 & CON2 appears across the top three resistors and parallel capacitor. Given the 1414V peak rating of the device, the resistors must therefore be able to handle at least 500V and the 10pF capacitor, 1.5kV. Similarly, the 100pF capacitor sees 9% of the total voltage and thus must be rated for at least 150V.

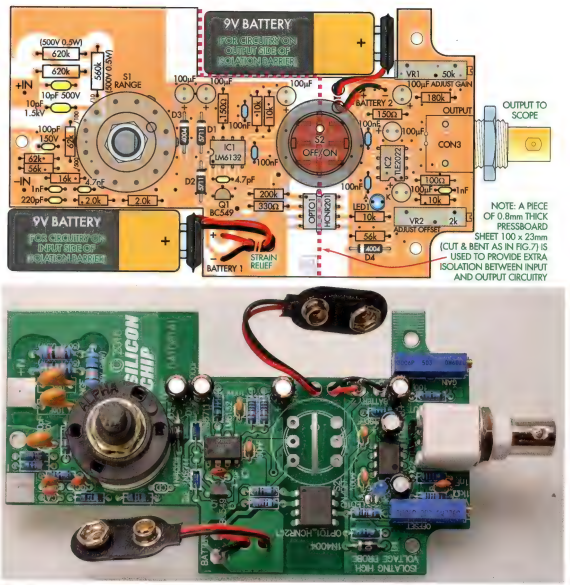


Fig.4 (top): the component overlay, which matches the near-same-size photo of the early prototype PCB (above). Note that the PCB is double-sided – make sure you solder the components to the correct side! S2 is not yet soldered in place in the photo but is shown in situ above.

Diodes D1 and D2 provide overvoltage protection for IC1a, ensuring that input pin 3 cannot swing higher than 0.4V above the input circuit's positive supply rail (V1+) or lower than 0.4V below its negative rail (V1-). This prevents IC1 from damage should you accidentally connect the probe inputs to high voltages when switch S1 is switched to the low voltage (÷10) range.

The 100Ω resistor at IC2a's output isolates this buffer from any cable capacitance or input capacitance of the scope.

We've also added a 1nF capacitor to form an RC low-pass filter here, to compensate for a peak in the frequency response of the circuit surrounding the opto-coupler just below 1MHz (ie, its roll-off point). This gives a flatter frequency response (Fig.3).

Note that we've also shown some alternative divider component values in the circuit. If used, these change the ÷500 range to ÷200. This results in a better signal-to-noise ratio but with a more limited input voltage range before saturation (see table in Fig.2).

Note that the resulting 800V peak rating is sufficient for working with even 3-phase mains.

Power supply

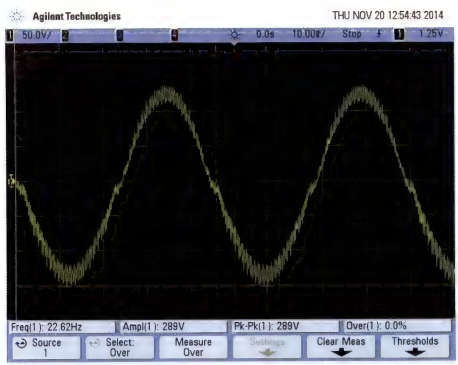
Importantly, the input and output circuits of the probe must be operated from separate power supplies, since they are on opposite sides of the isolation barrier.

So each section operates from its own 9V alkaline battery, with the input section running from battery 1 and the output section from battery 2.

We are using op amps 1C1b and IC2b as buffers to give each supply its own half-supply "reference ground". The buffers are very similar, in each case using a resistive divider to establish a battery "centre tap", with the ICs connected as voltage followers to provide the necessary current capability.

(The 150Ω resistors and 100µF capacitors are to ensure that the voltage followers remain stable.)

In the case of the input circuitry, the purpose of IC1b is to establish a "reference ground" voltage level for the negative input connector CON2, so that when there is no input to the



Scope3: the voltage across two outputs of the Induction Motor Speed Controller with an incandescent lamp as a load. The scope performs a sort of averaging when zoomed out like this, revealing the PWM-modulated sinewave shape.

probe the non-inverting input of IC1a is biased midway between the V1+ and V1– rails. This allows the input circuit to operate the IR LED inside OPTO1 at close to "half brightness", while also allowing IC1a to cope with the maximum possible AC voltage swing.

On the output side, IC2b is again there to provide a half-supply reference ground, for the output connector CON3. And by making the exact reference voltage variable using trimpot VR2, we allow cancelling of any output offset voltage that might be caused by differences between the photodiodes inside OPTO1 at the quiescent current level.

Although the two supplies are on opposite sides of the probe's isolation barrier, we switch them on and off in tandem using S2a and S2b, the two poles of a 250VAC-rated rocker switch.

Typical mains-rated switches of this type are rated to withstand 1000V RMS, which just happens to be exactly what OPTO1 is able to withstand.

To be safe, we've added some extra insulation between the leads connecting to the switch (as we'll explain soon).

Diodes D3 and D4 are connected to the switch such that the are reverse-biased normally and thus do not affect circuit performance at all. But if a battery happens to be connected backwards while S2 is on (easy enough to do, at least briefly), the diode will limit the voltage applied to IC1 or IC2 to no more than -1V, protecting it from damage.

LED1 is fitted to make it harder to forget to turn the unit off when you've finished using it. As it's a high-brightness blue LED, it only requires 100µA to operate, so it doesn't add much to the battery drain during operation.

Building the probe

As mentioned earlier, all of the components and circuitry of the probe are built into a small ABS instrument case measuring 150 x 80 x 30mm.

In fact everything except the two 9V batteries, on/off switch S2 and input jacks CON1 and CON2 is mounted on a single PCB measuring 122 x 70mm and coded 04108141. The board has cutouts on each side to provide spaces for the two 9V batteries, as you can see from the overlay diagram of Fig.4.

On/off switch S2 mounts on the top of the case on the centre line and about 1/3 of the distance up from the output end, with short insulated and splayed leads connecting its lugs to the matching pads on the PCB.

The two insulated input jacks CON1 and CON2 mount in the input end panel of the case with their connection lugs wired to the matching pads on that end of the PCB.

Output BNC connector CON3 is mounted directly onto the PCB at the centre of the output end, with trimpots VR1 and VR2 spaced equally on either side. The trimpots are then easily adjusted using a small screwdriver or alignment tool, through matching holes in that end of the case.

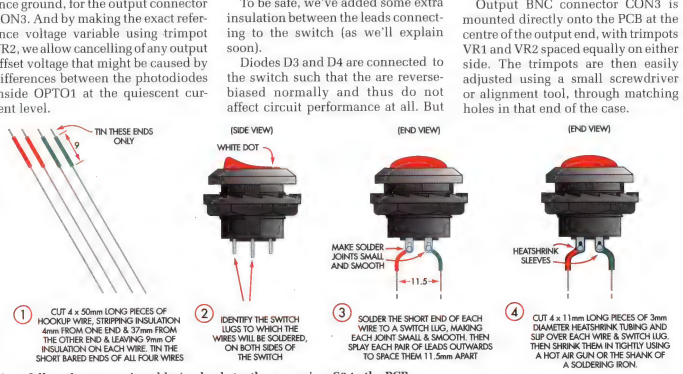


Fig.5: follow these steps in soldering leads to, then securing, S2 to the PCB.

To wire up the probe PCB, fit the components in the usual order: first the resistors (including VR1 & VR2), followed by the four diodes, the smaller capacitors and the six 100µF electrolytics – taking care to fit the diodes and electrolytics with the correct polarity. Take care not to get the two types of diode mixed up.

Next, mount transistor Q1, followed by the range switch S1, after cutting its spindle at a distance of 12mm from the end of the threaded ferrule. Then fit the switch to the PCB, taking care to use the orientation shown in Fig.4. Next fit IC1 and IC2, again making sure you orientate each one as shown.

The next component to be added to the PCB is the HCNR201 linear analog optocoupler (OPTO1).

Although it comes in an 8-pin DIL package, it has wider pin spacing than usual: 0.4" (10.16mm) rather than 0.3" or 7.62mm. It's fitted to the PCB with the "notch" end towards the top.

After this fit BNC output connector CON3 at the right centre of the PCB, midway between trimpots VR1 and VR2, followed by the four PCB terminal pins used to make the connections between the two battery snap leads and the PCB.

Two of these pins are soldered into the pads just below the cutout for Battery 1 at upper left, while the other two go just to the left of the cutout at lower right, for Battery 2. You can see these quite clearly in Fig.4.

Mount LED1 with the bottom of its lens 20mm from the top of the PCB. This will be with virtually the full lead length.

Finally, cut the two battery snap leads themselves to about 45-50mm long (measured from the snap) and strip back about 5mm of the insulation from the wire ends.

Thread the wires through the stress relief holes provided on the PCB and solder them to the terminal pins, again as shown in Fig.4.

Your probe PCB assembly should now be complete, and can be placed aside while you prepare the box.

Preparing the box

There are no holes to be drilled in the bottom half of the case. All of the holes are drilled and/or reamed in the top half and in the two removable end panels. But as there are only nine holes in all, this shouldn't be a problem. The size and location of all of the holes are shown in a drilling guide PDF which can be downloaded from siliconchip.com.au

After drilling the smaller holes and reaming the larger holes to size, use a jeweller's file or a sharp hobby knife to remove any burrs left around each hole on both the inside and the outside.

To make a "dress" front panel for the probe you can make a photocopy of our artwork in Fig.8 (or download it from siliconchip.com.au) and then laminate it in a plastic sleeve for protection. After this it can be trimmed to size and attached to the top of the case using double-sided adhesive tape. Then cut holes in the dress panel for fitting the top PCB mounting screw, S2 and the control spindle for S1, using a sharp hobby knife and guided by the holes you have already cut and reamed in the case underneath.

Making the isolation barrier

Before you begin fitting everything into the case, you need to prepare the isolation barrier which will provide additional isolation between the input and output circuitry and their batteries.

The barrier is cut from a 100 x 26mm

Parts List – Isolating High Voltage Probe for Oscilloscopes

1 PCB, code 04108141, 70 x 122mm
1 ABS instrument box, 150 x 80 x 30mm [Jaycar HB-6034]
1 4-pole 3-position rotary switch, (S1)
1 knob to suit S1, <25mm diameter
1 DPDT, 250VAC-rated rocker switch, single hole mounting (S2) [Jaycar SK-0994]
2 banana sockets, fully insulated, 1 red, 1 black (CON1, CON2)
1 PCB-BNC socket (CON3)
1 6mm long untapped spacer
1 15mm long M3 tapped Nylon spacer
1 15mm long M3 Nylon machine screw (cut from a 25mm long screw)
1 6mm long M3 machine screw
2 16.5mm long untapped spacers (cut from 25mm long spacers)
2 25mm long 6G or 7G countersunk self tapping screws
4 3.5mm ID flat washers
2 9V alkaline batteries
2 battery snap leads to suit
4 PCB terminal pins
1 100 x 26mm piece of 0.8mm Pressboard or Presspahn/Elephantide sheet

Semiconductors
1 LM6132AIN/BIN dual high speed op amp (IC1) [element14 order code 9493980]
1 TLE2022CPE4 dual low current op amp (IC2) [element14 order code 1234686]
1 HCNR201-050E high speed linear optocoupler (OPTO1) [Digi-Key 516-2379-5-ND]
1 BC549 NPN transistor (Q1)
1 3mm blue LED (LED1)
2 1N5711 Schottky diodes (D1,D2)
2 1N4004 1A diodes (D3,D4)

Capacitors
6 100µF 10V/16V PC electrolytic
4 100nF multilayer monolithic ceramic
1 4.7nF 50V disc ceramic
2 1nF 50V disc ceramic
1 220pF 50V disc ceramic
1 100pF 150V* disc ceramic
2 10pF 1.5kV* disc ceramic
1 4.7pF C0G/NP0 disc ceramic

* 7.62mm lead spacing; 3kV types suitable

Changes for 200:1 option:
- **Delete 220pF & 4.7nF ceramic capacitor**
- **Add three more 1nF ceramic capacitors**
- **Delete 16kΩ & two 2kΩ resistors**
- **Add two more 10kΩ resistors**

Resistors (1% metal film 1/4W unless specified)
2 620kΩ 500V 1% 1/2W
1 560kΩ 500V 1% 1/2W (eg, Vishay HVR37)
1 200kΩ
1 180kΩ
2 62kΩ
2 56kΩ
1 16kΩ
4 10kΩ
2 2.0kΩ
1 330Ω
2 150Ω
1 100Ω
1 50kΩ multi-turn horizontal adjustable trimpot (VR1)
1 2kΩ multi-turn horizontal adjustable trimpot (VR2)

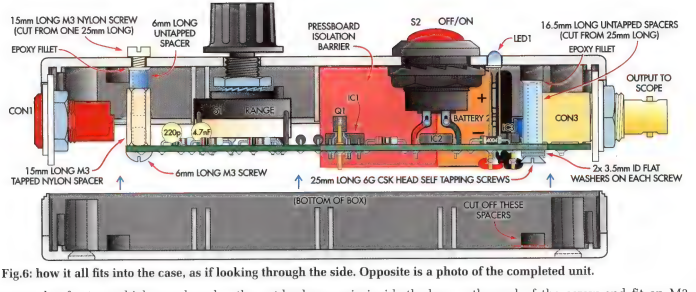


Fig.6: how it all fits into the case, as if looking through the side. Opposite is a photo of the completed unit.

rectangle of 0.8mm thick pressboard sheet (similar to Pressphan Elephantide), using the upper diagram of Fig.7 as a guide, and then bent up as shown in the lower diagram.

Preparing S2

The next step is to prepare on/off switch S2 by fitting it with the four well-insulated wires which will connect it to the PCB. As you can see from Fig 5.1 this needs four 50mm lengths of insulated wire, each with the insulation stripped by 4mm from one end but 37mm from the other end. (The long bared ends are to make assembly easier later.)

We are using the two centre lugs and those at the ends opposite to the white dot on the red rocker actuator at the top of S2, as shown on the left in Fig 5.2.

After soldering the short ends of the four wires to these switch lugs, each pair of wires is splayed away from the other pair as shown Fig 5.3, so that the pairs are spaced about 11.5mm apart.

Then cut four 11mm-long lengths of 3mm diameter heatshrink tubing, and push each of these sleeves up one of the wires as far as it will go – that is, over the switch lug and the solder joint and until its top end is hard against the rear of the switch body (see Fig 5.4).

After this use a hot air gun or the hot shank of your soldering iron to shrink each of the sleeves firmly into position around the wires and switch lugs. Then your "S2 switch assembly" should be complete, and ready to be fitted into place in the 18mm hole on the top of the case.

This is done by unscrewing the large plastic nut, and then passing the switch and its splayed wires down into the box via the 18mm hole. Then screw the nut back on again inside the box, to hold it in position.

But before you tighten the nut completely, make sure that the switch is positioned so that the white dot on its rocker actuator is positioned on the right, directly in line with the "ON" label of the dress front panel.

Next, cut the two 25mm untapped spacers down to a length of 16.5mm, using a jeweller's saw and smoothe off the cut ends using a small file.

Then fasten them temporarily to the two mounting spacers moulded into the inside of the top of the case (at the output end), using the two 25mm long countersink-head self tapping screws with about five or six small flat washers under each screw head as packing, so the screws don't enter the moulded spacers very far – just enough to hold the 16.5mm spacers in place.

Then pass a 15mm long Nylon M3 screw (cut from a 25mm long screw) down through the central hole near the input end of the case front panel, slip the 6mm untapped spacer up over the end of the screw and fit an M3 nut – screwing it up to hold the 6mm spacer firmly against the underside of the front panel.

You should now be almost ready to apply a fillet of epoxy cement around the top end of each of the three spacers, to hold them in place securely.

But there's one more thing to do first: fit the Pressboard isolation barrier into the top half of the case. Its 26mm-high "L section" should be over on the side ready to slip into the cutout for battery 2, with the 20mm-high section with its cutouts for S2 and OPTO1 passing "east-west" and aligned centrally between the contacts at the rear of S2.

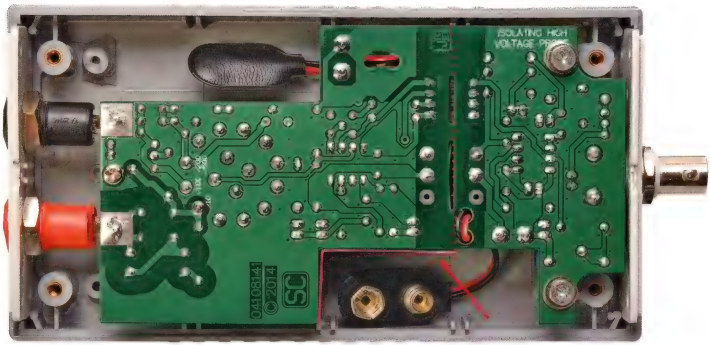
Once you're happy that it's in the correct position, it can be secured there using a few small dabs of epoxy adhesive between the barrier and the inside of the case top.

Then while you have the epoxy cement mixed up, cement the spacers to the case top as well.

When the cement has had time to cure, you can unscrew both of the

Resistor Colour Codes

No.	Value	4-Band Code(1%)	5-Band Code (1%)
2	620kΩ	blue red yellow brown	blue red black orange brown
1	560kΩ	green blue yellow brown	green blue black orange brown
1	200kΩ	red black yellow brown	red black black orange brown
1	180kΩ	brown grey yellow brown	brown grey black orange brown
2	62kΩ	blue red orange brown	blue red black red brown
2	56kΩ	green blue orange brown	green blue black red brown
1	16kΩ	brown blue orange brown	brown blue black red brown
4	10kΩ	brown black orange brown	brown black black red brown
2	2.0kΩ	red black red brown	red black black brown brown
1	330Ω	orange orange brown brown	orange orange black black brown
2	150Ω	brown green brown brown	brown green black black brown
1	100Ω	brown black brown brown	brown black black black brown



Take note of the order of assembly in the text, especially the Presspahn isolation barrier (arrowed) which wraps around the lower battery and sits across the middle of the PCB, as indicated by the red dotted line. This is all necessary to ensure good isolation between the battery and PCB and between the two poles of the power switch.

25mm long self-tappers and remove all but two of the washers on each, ready to secure the PCB shortly.

At the same time you can unscrew the 15mm M3 screw and its nut holding the 6mm spacer in place, and you'll be ready for final assembly.

Final assembly

The next step is to attach the 15mm long M3 tapped spacer to the PCB (at top centre), using a 6mm long M3 screw passing up from underneath. It's a good idea to tighten this screw firmly (but not TOO firmly) using a screwdriver, with the spacer held by a small spanner or nut driver.

After this, mount the two input connectors CON1 and CON2 into the input end panel of the case, with the red one on the right as viewed from behind the panel. Tighten their nuts to secure them in place, and then solder a short length of tinned copper wire to the rear lug of each connector.

Capacitor Codes

Value	µF value	IEC code	EIA code
100nF	0.1µF	100n	104
4.7nF	NA	4n7	472
1.0nF	NA	1n	102
220pF	NA	220p	221
100pF	NA	100p	101
10pF	NA	10p	10
4.7pF	NA	4.7p	4p7

Then, with the centre axis of the two connectors positioned about 6mm above the top end of the PCB, solder each wire to its matching pad on the PCB. These pads are provided with a centre hole, so you can pass each wire down through the hole before soldering.

Next, fit the output end panel of the case over the shank of CON3, after removing its nut. Then screw the nut back on again, to complete the PCB-and-end panels assembly.

By now you should be ready to fit this completed board assembly up into the top half of the case, by introducing it so that each of the two end panels slips into the matching slots in the ends of the case half, the four wires from S2 pass down through their matching holes in the PCB and the shaft and threaded ferrule of rotary switch S1 passes up through its matching hole in the top of the case.

When the assembly can't be pushed in any further, you should be able to secure it all together by screwing the two self-tapping screws back into the matching holes of the mounting spacers moulded into that end of the case top, and also by passing the 15mm long Nylon screw down through the matching hole in the centre of the input end of the case top, so it passes down through the 6mm untapped spacer and can then be screwed into the top of the 15mm long M3 tapped spacer.

If you found this description somewhat confusing, try looking at Fig.6. This shows what you'll be working towards.

When the PCB assembly is secured

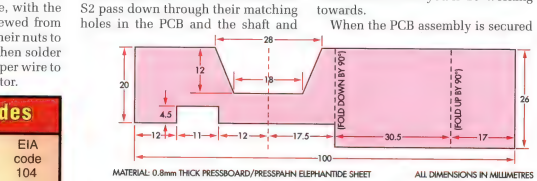
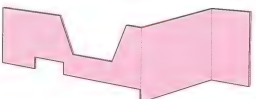


Fig.7: here's how to cut and fold the sheet of insulation material. It forms a physical barrier between the input and output sides.



in place as shown in Fig.6, you'll be able to fit switch S1's spindle with its control knob. Of course you'll also need to solder the wires from S2 to their pads on the PCB, after which you can cut off their excess lengths.

All that remains now is to attach each 9V battery to its snap connector, and then lower it into its waiting "slot" at the side of the PCB.

The final assembly step is to fit the bottom of the case and fasten it in place with the four 20mm long countersink head M3 screws supplied with it. However just before you do this, you'll need to cut off the two PCB mounting spacers moulded into the bottom of the case at the output end.

This is because if left in situ, they'll interfere with the heads of the mounting screws on the underside of the PCB. It's not hard to cut off these spacers with a pair of sharp side cutters.

After these "minor trimming" jobs, you should find that the bottom of the case will mesh nicely with the PCB-and-top assembly, allowing you to fit the four screws holding it all together.

Set-up & calibration

There isn't much involved in setting up and calibrating the probe.

The first step is to connect a DMM (set to read DC volts, on its 2V range) to the probe's output connector CON3 using a cable ending in a BNC plug. Now turn range switch S1 to the "/500" position, and also plug two input leads into CON1 and CON2. Connect their far ends together to make sure the probe definitely has "zero input".

Next turn on the probe's power switch S2, and you'll probably see the DMM reading move to a value slightly above or below 0V. The idea now is to adjust trimpot VR2 (Offset Adjust) in one direction or the other with a small screwdriver or alignment tool, to bring the reading as close as possible to 0V.

This is the initial setting for VR2. However, it may have to be readjusted by a small amount after you have performed the second step – calibration.

To calibrate the probe, the simplest approach is as follows. First connect its output (at CON3) to an input of your scope or DSO, using a reasonably short BNC-to-BNC cable. You can adjust the scope's input sensitivity to, say, 1V per division and if it has a switch or option for setting its calibration to allow for a probe's division ratio, set this to the 10:1 position. (This should change the effective input sensitivity to 10V/division.)

Next turn the probe's range switch S1 to the /10 position (fully clockwise) and connect the probe's input leads to a source of moderately low voltage AC.

This can be from an audio generator set to provide a sine-wave at about 1kHz with an output level of say 10V RMS (= 28.8Vp-p) or a square wave or function generator set to provide a square wave of again 1kHz at about 20 - 25Vp-p.

Or if you don't have access to either kind of generator, you could use a step-down transformer with a known (ie, measured) secondary voltage of around 12-15V RMS (= 34 – 42.4Vp-p).

When you now turn on the probe's on/off switch (S2), you should see the waveform from your signal source on the scope's display. Its frequency and amplitude should also be displayed if your scope has this facility built in, as most do nowadays.

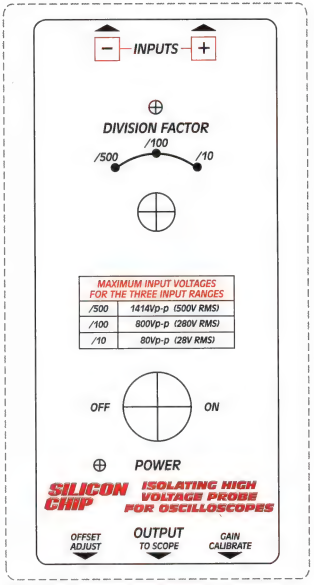


Fig 8: same size front panel artwork – photocopy this (or download it from siliconchip.com.au) and glue it to your box before inserting S2.

Now the odds are that while the frequency reading will be correct (either 1kHz or 50Hz as the case may be), the amplitude reading will probably be a little higher or lower than the known level of the signal being fed into the probe.

So what's needed now is to adjust the probe's "Gain Calibrate" trimpot VR1 in one direction or the other using a small screwdriver or alignment tool, to bring the reading as close as possible to the correct value.

After doing this calibration step, it's a good idea to go back and repeat the first "Offset Adjust" step – especially if you had to turn VR1 quite a few turns to achieve calibration.

This is done quite easily, simply by removing the probe's input leads from your source of AC and connecting them together. Then after turning the range switch to "/500", you can reconnect the probe's output to your DMM and check what reading you get.

If it has moved slightly away from the "0V" mark, it's simply a matter of adjusting trimpot VR2 to bring it back again. Then your probe will be set up, calibrated and ready for use. SC

Where is your vehicle? your package? your machine? Find it with TraceME!

Introducing the new TM-203

The TM-203 is the newest addition to our family of TraceME products.

Unique features:

- Very small fully-featured GPS Tracker (87 x 22 x 7 mm)
- Weighs only 15.5 grams, including GPS, GSM and RF antennas
- Advanced power saving, down to 3uA
- Location-based positioning (LBS) inside buildings
- Portable or externally connectable to integrate multiple sensors
- On-board sensors for compass, temperature and acceleration
- Worldwide coverage: Quad-band GSM/GPRS • Glonass/GPS • Wifi
- Complies with additional standards for insurance benefits (e.g. SCM and Incert)
- Complies with automotive safety standard (E-mark)

We would like to invite you to have a look around our website and get inspired by the possibilities of what KCS TraceME products can bring to your project. Whether you need a solution for personal tracking, trace and control vehicles, object protection or more advanced M2M solutions, KCS TraceME can deliver it.

GPS/GPRS enabled GPS Tracker with advanced I/O. This will allow you to remotely track & trace and/or control a huge diversity of objects, machines and/or vehicles. KCS TraceME is absolutely the most versatile and adaptive Track-n-Trace solution in the market today. Our clients use the TraceME hardware for the most diverse tasks. It is truly an all-round performer and exceeds anything in the market currently available.

- KCS TraceME is available in different form factors (Key fob, OEM., Aluminum & custom made casing);
- GPRS, UMTS, SMS, GSM, Wi-FI, RFID, E-mail;
- Fully configurable administration tool;
- Event driven, can run custom code, remotely configurable;
- Connect M2M to any device;
- G-shock detection, temperatures, tilt, motion, iButtons, mobile phones, camera's;
- See the rest of the site for the full options!

Please contact us if you want to discuss your ideas!

OEM & Distributor requests are welcome!

www.Trace.ME

All trademarks mentioned herein belong to their respective owners.

High-Energy Multi-Spark CDI For Performance Cars

Pt.2: By JOHN CLARKE

Six Versions To Suit Your Car's Trigger Source

In Pt.1 last month, we introduced our new High-Energy Multi-Spark CDI and described its operation. In this article, we give the assembly details for six different versions to suit your car's trigger source and describe the installation.

THE ASSEMBLY of the Multi-Spark CDI is straightforward, with all parts installed on a double-sided PCB coded 05112141 (110.5 x 85mm). This PCB can be obtained either as part of a complete kit (ie, from parts retailers) or can be purchased from the SILICON CHIP Online Shop.

Fig.5 and Figs.6(a)-6(e) show the parts layouts to suit different ignition pick-up versions. It's simply a matter of building the version to suit the ignition pick-up in your car.

The first step is to install surface mount chips IC1, IC2 & IC3. These are in SOIC packages, so they are not that difficult to solder in place due to their relatively wide 0.05-inch pin spacing. Each IC is mounted on the top of the PCB and must be orientated as shown on Fig.5.

Note that pin 1 is difficult to discern on IC3. However, if you look at the end profile of the IC, there will be a chamfer down one edge. This side has pins 1-4.

To solder an IC in place, you will need a soldering iron with a fine tip

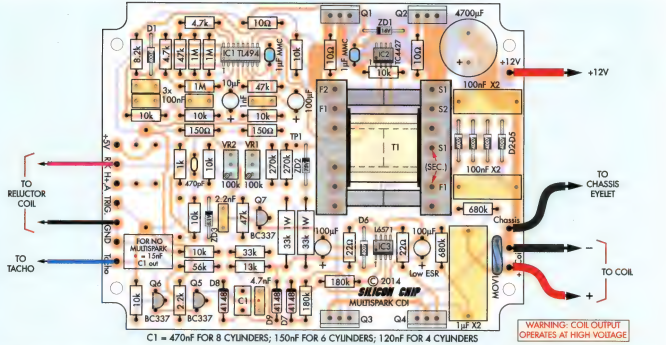


Fig.5: follow this PCB layout diagram if your car's distributor has a reluctor pick-up. Be sure to install the three SMD ICs (IC1-IC3) first and note that capacitor C1 must be chosen to suit the number of engine cylinders. Alternatively, leave out C1 and change the adjacent 4.7nF capacitor to 15nF if you wish to disable the multi-spark feature.

and some "no-clean" flux paste. Begin by carefully placing the IC on top of its pads, ensuring that its orientation and alignment are correct. That done, place a dab of flux paste on one of the corner pins, then put a little solder on the tip of your soldering iron and touch the pin gently, without disturbing the IC. The flux paste should help "suck" the solder onto that pin and pad.

Now check the IC's alignment. If it's out, reheat the joint and gently nudge it into place. Once the alignment is good, use the same technique to solder the diagonally-opposite pin.

It's then just a matter of soldering the remaining IC pins and cleaning up any bridges using solder wick. Refresh the joints on the first two pins you soldered, too. Adding no-clean flux paste is recommended for both procedures; when soldering the pins, it reduces the chance of bad joints.

Finally, clean off any excess flux using an appropriate solvent (metho will do in a pinch) and check the joints under magnification to ensure that solder has flowed properly onto every pin and pad.

Once the ICs are in place, the through-hole parts can be installed, starting with the resistors, diodes and zener diodes. Table 1 shows the resistor colour codes but you should also check each one with a multimeter before fitting it to the PCB.

Be sure to orientate the diodes and zener diodes as shown on Figs.5 & 6. The zener diode type numbers are shown in the parts list.

Mosfets Q1-Q4 are next on the list. These must all be installed so that the tops of their metal tabs are 20-25mm above the PCB. The easiest way to do that is to first loosely fit all the devices in place, then rest the board upside down on 20-25mm-high supports (one at either end). The Mosfet devices can then be pushed down so that their tabs rest against the bench-top and their leads soldered.

Once these parts are in, you can install the capacitors. Note that the electrolytic types must be orientated with the correct polarity (ie, negative lead towards the top edge of the PCB in each case). Note also that the 4700µF and 100µF capacitors must be low-ESR types.

Multi-turn trimpot VR1 can now go be fitted. It goes in with its screw adjustment end towards the bottom edge of the PCB (ie towards Q7).

Transformer winding

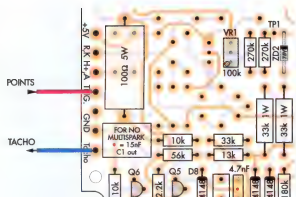
Fig.7 shows the transformer details. It's made up by first installing three windings on an ETD29 13-pin bobbin: a 240-turn secondary winding and two primary windings. The bobbin is then fitted to two N87 ferrite cores to complete the assembly.

The secondary winding goes on first and is wound using 240 turns of 0.25mm-diameter enamelled copper wire (ECW), about 20m long. The first step is to scrape away about 10mm of the insulation from one end using a sharp hobby knife. This end is then soldered to pin 10 (S1) on the 7-pin

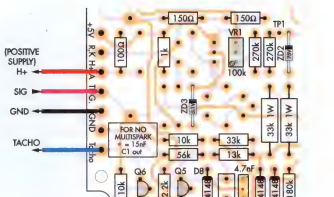
Warning – High Voltage!

This circuit produces an output voltage of up to 300V DC to drive the coil primary and is capable of delivering a severe (or even fatal) electric shock. DO NOT TOUCH any part of the circuit or the output leads to the coil from CON2 while power is applied.

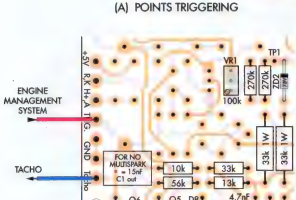
To ensure safety, the PCB assembly must be housed in the recommended diecast case. This case also provides the necessary heatsinking for the four Mosfets.



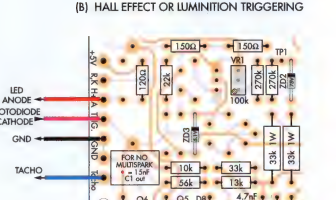
(A) POINTS TRIGGERING



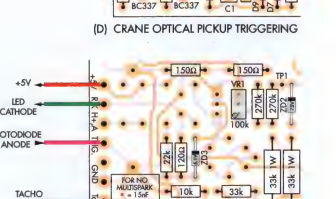
(B) HALL EFFECT OR LUMINITION TRIGGERING



(C) ENGINE MANAGEMENT TRIGGERING



(D) CRANE OPTICAL PICKUP TRIGGERING



(E) PIRANHA OPTICAL PICKUP TRIGGERING

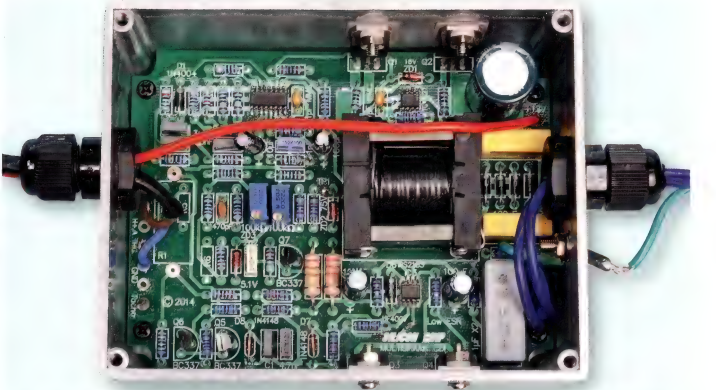
Fig.6(a)-(e): here's how to mount the parts on the input section of the PCB to suit other ignition trigger types. It's just a matter of choosing the layout to match your car's ignition trigger and then mounting the remainder of the parts as shown on Fig.5. Note that the 100Ω 5W resistor used in the points triggering version should be secured to the PCB using neutral-cure silicone, to prevent it from vibrating and fracturing its leads and/or solder joints.

side of the bobbin (see Fig.7).

The next step is to wind on four 60-turn layers. Begin by winding the wire clockwise, with the turns placed side-by-side, until the first 60-turn layer is completed. The winding should end up near the edge of the bobbin on the opposite side to the S1 start pin.

Cover this winding with a single layer of insulation tape, taking care to also cover the start of the wire as it comes down from the bobbin pin. The next 60-turn layer can then be wound on in the same clockwise direction, again with the wires close-wound and laid side-by side. Cover this winding with another single layer of tape, then complete the other two 60-turn layers in exactly the same manner, finishing with another layer of tape.

The end of the winding is now trimmed, stripped of insulation and soldered to pin 8 (F1), as shown. As before, make sure that the wire end is covered with a layer of insulation tape as it exits from the bobbin to connect to the pin. The idea is to make sure that the secondary winding will be electrically isolated from the primary windings.



This inside view shows the completed High-Energy Multi-Spark CDI with the parts installed for a reluctor pick-up trigger (see Fig.5). Be sure to use heavy-duty automotive cable for the external wiring connections.

Fig.7: the winding details for transformer T1. The secondary is wound first using four 60-turn layers of 0.25mm-diameter enamelled copper wire (ECW), starting and finishing at pins 10 & 8. The primary is then wound on using eight bifilar turns of 1mm-diameter ECW, starting at pins 13 & 12 and finishing at pins 2 & 1 respectively.

The primary windings are wound using two separate 600mm lengths of 1mm ECW. Start by scraping about 10mm of insulation from one end of each wire, then wrap and solder them to pins 13 & 12 on the bobbin.

The two primary windings are now wound on together (ie, bifilar wound). It's just a matter of winding on eight turns and then connecting the wire ends to pins 1 & 2. Note that the wire that starts at S1 (pin 13) must connect to F1 (pin 2), while the wire from S2 (pin 12) must connect to F2 (pin 1).

You can identify the windings using a multimeter. There should be close to 0Ω between S1 & F1 and close to 0Ω between S2 & F2. Conversely, there should be high impedance (>1MΩ) between S1 & S2 and between the two primary windings and the secondary.

Once the primary has been completed, cover this winding with a single layer of insulation tape cut to fit the inside width of the bobbin. It's then just a matter of sliding the two ferrite cores into the bobbin and securing them in place using the supplied clips.

The transformer assembly can now be installed on the PCB. It can only go in one way, since one side of the bobbin has six pins while the other has seven. Be sure to push the transformer all the way down onto the board before soldering its pins.

The PCB assembly can now be completed by soldering long lengths of heavy-duty automotive cable to the PCB wiring points for the +12V supply, trigger inputs, coil connections and tacho connection. The chassis connection (near the coil connections) goes to

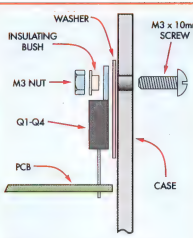


Fig.8: the mounting details for Mosfets Q1-Q4. The metal tab of each device must be insulated from the case using an insulating bush and silicone washer. Do the mounting screws up firmly, then use a DMM to make sure each tab is indeed insulated from the case.

a solder lug that's secured to the case, so this lead can be kept short.

Preparing the case

The completed PCB assembly is housed in a diecast metal case measuring 119 x 94 x 57mm. This has to have a number of holes drilled in order to mount the PCB, secure the tabs of Q1-Q4 and fit cable glands.

Start the case preparation by drilling the PCB mounting holes. To do this, first place the PCB assembly inside the case and mark out the four corner holes in the base. That done, remove the PCB, drill these holes out to 3mm diameter and remove any burrs using an oversize drill. These holes should then be countersunk on the outside of the case, to accept M3 countersink head screws.

Next, secure four M3 x 9mm tapped spacers to the PCB mounting holes using M3 x 6mm pan-head screws, reposition the PCB inside the case and mark out the tab mounting hole positions for Q1-Q4. Drill these out to 3mm diameter and lightly countersink them using an oversize drill to remove any sharp edges on the holes. This step is vital to prevent the insulating washers that fit between the Mosfet tabs and the case from being punctured.

While you are at it, drill a 3mm hole in the side of the case so that the earth solder lug can be attached. This lug can then be installed using an M3 x 6mm machine screw, nut and shakeproof washer.

Holes are also required in the left-hand and righthand ends of the case to accept the two specified cable glands. These two 15mm-diameter holes should be located 15mm down from the top of the case and 50mm in from the rear. You can drill the cable gland holes in one step using a 15mm Irwin Speedbor drill.

Alternatively, use a small pilot drill to start the holes, then carefully enlarge them to size using a tapered reamer. Remove any sharp edges and metal swarf using a rat-tail file.

Once all the holes have been drilled, install the PCB in the case and secure the spacers to the base using four M3 x 6mm countersink-head screws fed up through the base. Mosfets Q1-Q4 can then be fastened to the sides of the case as shown in Fig.8. In each case, this involves using a silicone washer and insulating bush to electrically isolate the device tabs from the case. Secure each tab assembly to the case using an M3 x 10mm machine screw and nut. You can also fit a shakeproof washer if you wish.

Now check that the tab of each device is indeed electrically isolated from the case. That's done simply by measuring the resistance between the case and each Mosfet tab using a multimeter. Each device should give a very high ohms reading, although the reading may initially be low and then quickly increase as the capacitors charge up via the multimeter's leads.

A permanent low ohms reading means there is a short between the tab of that particular device and the case. If that happens, undo the assembly, clear the fault (eg, metal swarf or a sharp edge on the mounting hole) and replace the silicone washer with a new one.

Finally, trim and solder the chassis wire to the earth lug and attach it to the side of the case.

The +12V lead should be fed through the left cable gland along with the trigger wires. The two ignition coil wires should pass through the right hand cable gland. Be sure to use heavy-duty automotive cable for all these connections and lace the wiring securely to ensure reliability.

Table 2: Capacitor Codes

Value	µF Value	IEC Code	EIA Code
100nF	0.1µF	100n	104
4.7nF	.0047µF	4n7	472
1nF	0.001µF	1n	102

Table 1: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	3	1MΩ	brown black green brown	brown black black yellow brown
❑	2	680kΩ	blue grey yellow brown	blue grey black orange brown
❑	2	270kΩ	red violet yellow brown	red violet black orange brown
❑	2	180kΩ	brown grey yellow brown	brown grey black orange brown
❑	1	56kΩ	green blue orange brown	green blue black red brown
❑	2	47kΩ	yellow violet orange brown	yellow violet black red brown
❑	3	33kΩ	orange orange orange brown	orange orange black red brown
❑	1	13kΩ	brown orange orange brown	brown orange black red brown
❑	7	10kΩ	brown black orange brown	brown black black red brown
❑	1	8.2kΩ	grey red red brown	grey red black brown brown
❑	2	4.7kΩ	yellow violet red brown	yellow violet black brown brown
❑	1	2.2kΩ	red red red brown	red red black brown brown
❑	2	22Ω	red red black brown	red red black gold brown
❑	3	10Ω	brown black black brown	brown black black gold brown

Note that running the +12V lead through the same clamp as the ignition coil would induce high voltage spikes into the +12V supply, so don't do this.

Testing

If possible, use a current-regulated power supply to initially test the DC-DC converter in the Multi-Spark CDI unit. **And here a word of warning: this inverter produces around 300V DC, so don't touch any part of the circuit while it is operating. For the same reason, it's important not to touch the output wires to the coil.**

Before applying power, it's a good idea to fit the lid on the box. Electrolytic capacitors have a nasty habit of exploding if they are installed with reverse polarity, so this simple step will protect your eyes. At the very least, wear eye protection if you intend operating the unit with the lid off.

If everything is OK when power is applied, then power off again and remove the lid. VR1 now has to be adjusted to set the converter's output to 300V. To do this, connect a multimeter between the chassis and test point TP1, then reapply power and adjust VR1 for a 300V DC reading **(be careful not to touch any part of the circuit).**

For a reluctor pick-up, VR2 has to be adjusted so that the pick-up sensitivity is correct. That's done as follows:

(1) Connect the reluctor to the CDI.

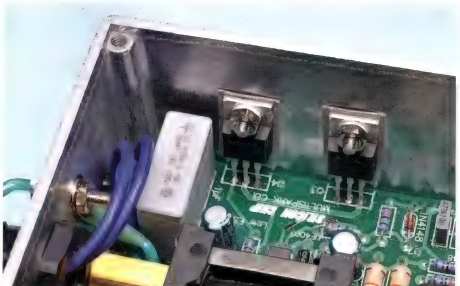
(2) Turn VR2's adjustment screw anti-clockwise by 10 turns, then adjust this screw clockwise until Q7's collector drops to 0V.

(3) Turn VR2's adjustment screw anti-clockwise so that Q7's collector just goes to about 5V, then adjust VR2 anticlockwise by two more turns (this ensures that Q7 is not prone to switching on and off with no reluctor signal).

Installation

Be sure to mount the CDI case in a splash-proof location where air flows over it and make sure that it is well away from the exhaust side of the engine. It can be secured inside the engine bay using self-tapping screws or you could use brackets. Make sure that the case is well-earthed to the vehicle chassis.

Once it's in place, connect the positive supply lead to the +12V ignition line and the trigger input to the ignition pick-up. The coil leads go to either side of the ignition coil primary. Disconnect any other wires that are part of the original ignition system. The tacho signal leads runs direct to the tachometer (again, disconnect the existing signal lead).



This view shows how Mosfets Q3 & Q4 are secured to the case for heatsinking. Make sure that their case mounting holes are free of any metal swarf before installing the insulating washers and mounting screws. Mosfets Q1 & Q2 are mounted in similar fashion (see Fig.8).

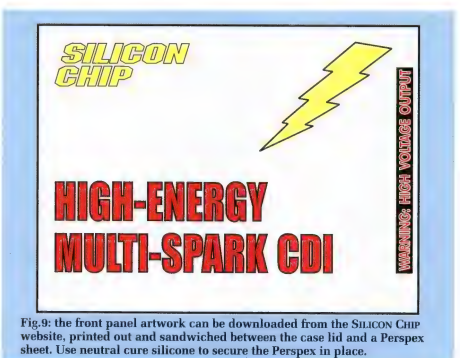


Fig.9: the front panel artwork can be downloaded from the Silicon Chip website, printed out and sandwiched between the case lid and a Perspex sheet. Use neutral cure silicone to secure the Perspex in place.

Note that a reluctor coil pick-up must be connected with the correct polarity in order to give the correct spark timing. This is best determined by testing the engine. If it doesn't fire, reverse the leads and try again.

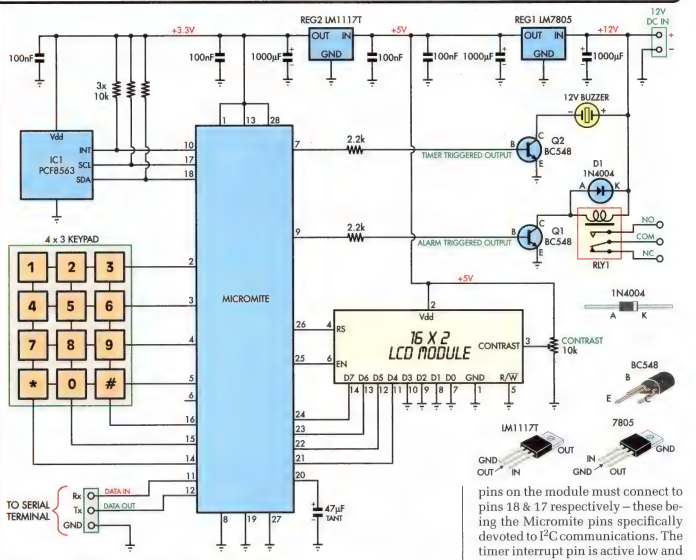
You may find that with the Multi-Spark CDI installed, the spark timing is a little advanced, due to the CDI's fast rise time. If so, you may need to retard the static timing slightly to prevent pinging or a slightly rough idle.

Note that it's always a good idea to turn the ignition on for one or two seconds before actually cranking the engine. This will allow IC3's 100µF filter capacitor to fully charge and give the inverter circuit sufficient time to generate its 300V DC output.

Once it's all working, use neutral cure silicone to seal the lip of the case, the cable glands and any mounting screws. This will ensure that the case is watertight and ensure reliability. SC

CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions will be paid for at standard rates. All submissions should include full name, address & phone number.



Using a Micromite to control a PCF8563 real-time clock

The Micromite has inbuilt time and date functions which are suitable for short-term time keeping. But if used continuously over extended periods, such as in a watering system or pool pump control, the clock will inexorably drift to such an extent that the devices may well be switched on when it is illegal to do so.

One solution is to hand over the time-keeping duties to a real-time clock chip such as the PCF8563. This chip needs a few additional components (including a 32.768kHz crystal) to turn it into an accurate time-keeper. The best way of doing this is to buy a PCF8563 real-time clock board. These boards have all the components already installed, ready to slot into this project. Just Google "pcf8563 rtc board" and you will find any number of suppliers selling the boards for about $6.

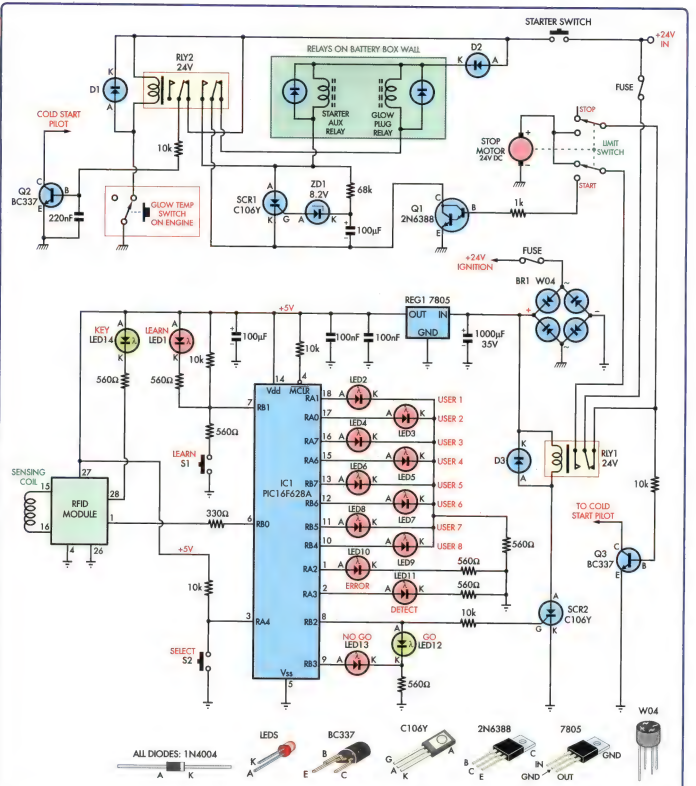
The PCF8563 keeps accurate track of the time and date and has two separate alarm functions. The first is the usual alarm based on the time of day, just as in a normal alarm clock. The second is a countdown timer as you might use for time exposure in a UV light-box. The countdown timer can count down from times as large as 255 minutes. Both alarms are implemented in this project and both can be operating simultaneously.

The circuit diagram shows how simple it can be to use this timer module with the Micromite. The PCF8563 uses a serial I^2C bus for communication but fortunately the Micromite makes using this protocol relatively simple. The SDA and SCL pins on the module must connect to pins 18 & 17 respectively – these being the Micromite pins specifically devoted to I^2C communications. The timer interrupt pin is active low and connects to Micromite pin 10. The three associated 10kΩ resistors function as pull-ups.

The interrupt can result from either the alarm or countdown timer (or both), and is used by the Micromite to switch either pin 9 or pin 7 high. Flags in the timer chip indicate which process(es) caused the interrupt(s) so that the correct pin(s) can be turned on.

A 4x3 keypad is used to enter timer and alarm data and a 16x2 LCD is used to display the time and date on line 1 and the state of both alarms on line 2. They are directly connected to the Micromite pins as shown. The circuit requires 12V, 5V and 3.3V DC supply lines and these are derived from a 12V plugpack feeding in series a 5V and a 3.3V regulator. Use a small heatsink on the 5V regulator.

When power is first applied, the correct time and date need to be en-



Engine immobiliser uses RFID tag

This circuit is based on the RFID tag project featured in the November 2010 issue of SILICON CHIP. It is available from Oatley Electronics, Cat. K291.

The circuit has been modified so that once the valid RFID tag has been sensed, the relay latches on permanently rather than being energised only briefly, as it would if it was being used to control a door lock solenoid. This change has been achieved by changing the relay switching transistor to a C106Y SCR (SCR2) which latches on, once triggered.

It was installed on a vehicle with a 3.9L 4 cylinder diesel engine and it simply prevents the motor being started if a valid RFID tag is not sensed. In this case, it prevents the 24V motor in the diesel shut-down

continued on page 48

tered. Pressing 1 on the keypad will prompt for the time to be entered in HHMMSS format. The entered digits are echoed on line 2 of the display.

When all six digits have been entered you will be prompted to enter the date in DDMMYY format. After this,

continued next page

RTC . . . continued from page 45

the display will show the time and date and the alarm states similar to that shown below (assuming the time and date entered are those shown):

14:27:35 26/10
no alarm no timr

Note that the full date cannot be displayed, through lack of space. You are expected to be able to remember what year it is!

To set the alarm, press 3 on the keypad and you will be prompted to enter the alarm time in HHMM format. When all four digits have been entered, the display might read:

14:29:47 26/10
07:30 no timr

The countdown timer is initiated by pressing 2 on the keypad. You will prompted to enter the countdown value which must be a number from 1-255. You will next be asked to name the units. Enter "2" if seconds or "3" if minutes are the units to employ. After entering the data, the display might look something like:

14:29:47 26/10
07:30 150 sec

This assumes, of course, that you entered 150 seconds for the countdown timer value.

While entering data at any of the above stages, "*" will act as a back space to erase an incorrect digit. "#" will abort the process and also turn off all alarms.

If the alarm is triggered, pin 9 goes high and activates the relay. This can be used to turn on a radio, for example. If the countdown timer is triggered, pin 7 goes high and in this case the buzzer will sound. You can substitute another relay in place of the buzzer if that suits your purpose.

If the alarm has been triggered, "*" will turn the alarm off (ie, set pin 9 low) but keep the alarm setting so that it will come on again at the same time the next day.

If the timer was triggered, it is automatically cancelled and will not count down again until new values are set. "*" will turn the alarm off (ie, set pin 7 low). Pressing "#" will turn both the alarm and timer off and cancel them.

The Micromite time and date are synchronised with the PCF8563 time and date once every day. The software, *rtcalarm.bas*, is available for download from the SILICON CHIP website.

Jack Holliday,
Nathan, Qld. ($60)

4-digit thermometer

This 4-digit thermometer is based on an ICL7135 precision analog-to-digital converter with multiplexed BCD output, digit driver and blinking outputs that give visual indication of over-range and under-range. The chip contains all the necessary active devices with the exception of display drivers, reference and clock. These are externally added to it in this circuit.

A silicon diode-connected transistor is employed as a sensing element. The full scale is set to 400mV (±199.9 counts) with the righthand-most digit displaying fractions of 1°C.

In the analog section, Q1 serves as a sensor with a temperature coefficient of -2mV/°C. The base-emitter junction of this transistor, which is forward-biased by a 4.7kΩ resistor, is connected to the IN LO input of IC1 at pin 9. The voltage on this diode is proportional to the temperature. At 0°C, the voltage is equal to 641mV. Thus VR2 should be set to 641mV at pin 10 (IN HI) for a display reading of 000.0 reading at 0°C.

The REF voltage on pin 2 of the chip is set to 200mV for 400mV (±199.9 counts) full scale. This means that the voltage on pin 9 of the chip can be within the range of +641mV (at 0°C) ±400mV. Beyond this range, the display will blink.

The clock is built around LM311 single comparator IC3 which is configured as an oscillator with its frequency set to 100kHz. This arrangement is suitable for both 50Hz and 60Hz mains power as it maintains good power supply rejection.

Each measurement cycle goes through four phases. They are (1) auto-zero, (2) signal-integrate, (3) de-integrate and (4) zero-integrator. Thus, the analog signal of the input is converted to a digital format.

IC2 is a BCD to 7-segment decoder that drives the common anode LED display. The four transistors tied to the anodes of the display serve as anode drivers.

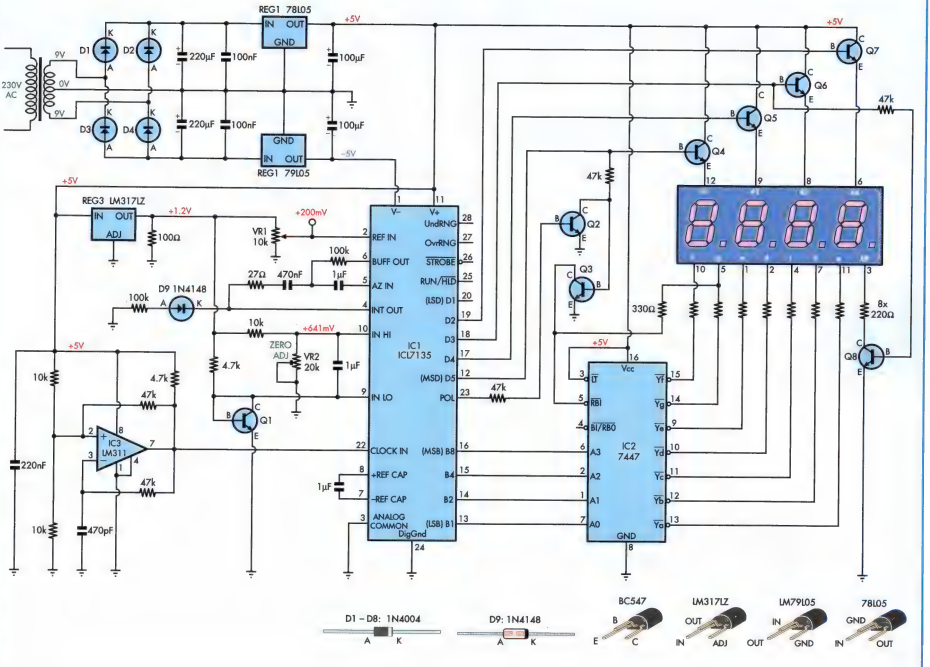
Transistor Q3 blanks the leading digit when the reading is negative but turns on its middle 'g' segment to show a minus sign. When Q4 applies voltage to this digit's anodes, the D5 output of IC1 is high and if the reading is negative, so is the POL output at pin 23. Thus the base of Q3 is pulled high which brings the ripple blanking input (RBI) at pin 5 of IC2 low, disabling IC2's outputs. The 'g' segment is then driven directly by Q3.

Transistor Q8 drives the decimal point when the third digit is active, indicating that the right-most digit represents increments of 0.1°C.

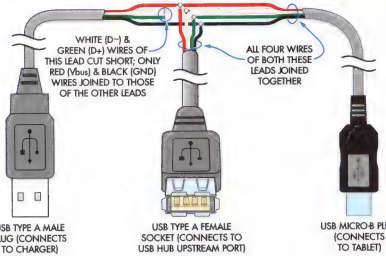
To calibrate the thermometer, make sure that VR1 is set for 200mV at pin 2 of IC5. Place the sensor in ice water and adjust zeroing trimpot VR2 for a display reading of 000.0. This will happen when the voltage on pin 10 of IC5 is adjusted to 641mV - or perhaps a slightly different value, depending on the properties of Q1.

Finally, place the sensor in boiling water and adjust scale-factor trimpot VR1 for a reading of 100.0 at sea level.

Mahmood Alimohammadi,
Tehran, Iran. ($50)


REG1 78L05
IN OUT
GND
+5V
9V
0V
9V
230V AC
D1
D2
D3
D4
220µF
100nF
100µF
GND
IN OUT
REG1 79L05
-5V
REG3 LM317LZ
ADJ
+1.2V
100Ω
+200mV
VR1 10k
100k
1µF
27Ω
470nF
D9 1N4148
IC1 ICL7135
V-
V+
UndRNG
OvrRNG
REF IN
BUFF OUT
STROBE
AZ IN
RUN/HLD
(LSD) D1
D2
D3
INT OUT
IN HI
D4
(MSD) D5
IN LO
POL
CLOCK IN
(MSB) B8
+REF CAP
B4
-REF CAP
B2
ANALOG COMMON
DigGnd
(LSB) B1
+641mV
ZERO ADJ
VR2 20k
4.7k
10k
47k
220nF
470pF
IC3 LM311
Q1
Q2
Q3
Q4
Q5
Q6
Q7
Q8
47k
330Ω
8x 220Ω
IC2 7447
Vcc
LT
RBI
BI/RBO
A3
A2
A1
A0
GND
Ya
Yb
Yc
Yd
Ye
Yf
Yg
D1 – D8: 1N4004
D9: 1N4148
BC547
LM317LZ
LM79L05
78L05

Don Amos is this month's winner of a $150 gift voucher from Rare & Forbes



USB OTG charging cable

You can now purchase 8-inch Windows tablets at a very low price. Typically, you get a quad core tablet with Windows 8 and Microsoft Office for less than $300. These are quite powerful and are capable of being used as desktop computers as they have HDMI ports that can drive 1920 x 1080 displays and they also have USB ports, allowing for expansion.

You can use a USB OTG (on the go) cable to convert the tablet's micro USB to a USB female connector and then use a range of USB devices. The USB OTG cable tells the tablet to stop behaving like a USB device and start behaving like a USB host. It does this by using the fifth pin on the micro-B connector to tell the tablet to use the USB OTG mode.

The big problem is that the micro USB is also the charging port, so you can either charge the tablet or use the USB port but not both at the same time. I spent a lot of time experimenting with cables and I found that while the tablet is in USB OTG mode it will not accept charge, so the tablet's battery will gradually run flat.

The solution is simple – don't use the OTG cable! It turns out that the tablets are quite happy to behave as a host when you use a non-OTG device cable and they will then accept a charge at the same time. This is done by making up a cable using the arrangement shown above.

You need to sacrifice two cables: a USB Type A male to USB micro-B (eg, Jaycar WC-7708) and a USB Type A male to USB Type A female (eg, Jaycar WC-7708). You should have the first cable already, as it came with the tablet. The second cable is just a USB Type A extension cable.

Cut both cables in half and put the extra USB Type A male cable aside – it is not required. Connect the white and green wires between the USB micro B connector and the USB Type A female connector, matching the colours as you go. Now connect all three red wires and all three black wires between the USB Type A male, USB Type A female and USB micro-B connectors. Insulate all your connections and you are ready to go.

Plug the USB Type A male connector into your existing charger, the USB micro B into the tablet and the USB Type A female connector into a powered USB hub (it does not need to be powered but this allows higher power devices). You can then plug keyboards, mice, USB sticks, hard disks and any other devices into the USB hub, and use them all at once. I found my tablet initially said "plugged in – not charging" but after a minute or so it changed to "plugging in – charging".

I also found that I can use any spare 5V regulated plugpack (1A and above) to charge the tablet instead of using the USB type A plug. Just connect the four wires from the USB Type A female to the USB micro-B and connect the 5V regulator to the red and black wires. This saves the original cable and charger so they can be used when you want to use the tablet as a tablet.

Don Amos,
Ingleburn, NSW.

Engine immobiliser –

continued from page 48

unit from rotating to the start position. On other vehicles, it could disable the ignition or stop the fuel flow with a solenoid valve. This would be done via the switch contacts of relay RLY1.

The RFID sensing coil was concealed inside the steering column of the vehicle and the tag is on the ignition key ring so that it can be read by the sensing coil once the ignition has been turned on. The tag is suspended on a piece of chain 60mm long.

The top section of the circuit is more or less incidental and is associated with the glow plug switching for a diesel engine where the plugs are energised for a brief period (3.5s) before the engine is cranked to start it.

Transistor Q1 controls a timer circuit to hold the start circuit off until the shut-down unit is in the start position. The 24V motor in the shut down unit goes in the one direction only, one half turn at a time, being controlled by the limit switches operated by a cam on the output shaft. The power has to be available to the relay contacts all the time, so as to be able to power the motor to the stop position when the ignition is turned off.

Note that since the circuit is being used in a 24V vehicle, relay RLY1 must have a 24V coil. Altronics Cat. S-4162 will fit into the RFID PCB from Oatley Electronics. In 12V vehicles, this change is not necessary.

Ron Groves,
Cooloola Cove, Qld. ($45)

Build your ultimate MAN CAVE RETREAT

Celebrate Summer from your couch!

jaycar electronics
Better. More Technical

NEW

FROM $69.95

Stage DMX LED PAR Lights

Add some colour to your gathering or next event with these super bright PAR lights. Each light can be controlled using the built-in program, sound activated via the built-in microphone, from the included remote control, or from a DMX controller. The supplied bracket allows temporary or permanent mounting.

- LED colours: Red, Blue, Green and White
- Sound control: Auto, remote control, DMX-512
- Mains powered
- Fan cooled
- 175(L) x 175(H) x 105(D)mm

18 X 1W LEDS ST-3600 **$69.95** (Shown)
7 X 4W LEDS ST-3602 **$99**

DMX Laser Light

SL-3451

$199

Create lasers at your next gathering, or special occasions. This model features an XLR out plug that allows you to daisy-chain multiple units together for full DMX controlled ambience.

- Laser colours: Red, Green & Yellow
- Sound control: Auto, DMX-512 (7 channels)
- Mains powered
- 363(L) x 143(W) x 67(H)mm

EXTRA REWARDS FOR YOUR LOYALTY!

LOOK INSIDE FOR GREAT DEALS...

Portable Stage DMX Light ST-3604

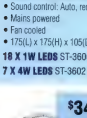
This LED moving stage light with seven extremely powerful 10W LED lights can pan 360° and tilt 180° to create dazzling light effects for your event. The light features changeable electronic strobes, dimmer functions and can be sound activated or DMX controlled. Extremely portable, only 2.8kg.

- LED colours: Red, Blue, Green and White
- Sound control: Auto, DMX-512 (18 channels)
- Mains powered
- 240(H) x 177(L) x 177(W)mm

NEW $299

$34.95

NEW



Stereo Hi-Fi Headphones

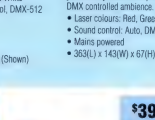
AA-2120

Listen to your favourite music in high fidelity with these professional build quality and stylish stereo headphones. Connect directly to your Smartphone, home theatre system and CD/DVD players. White.

- 3.5mm stereo plug

$39.95

NEW



Rechargeable Speaker

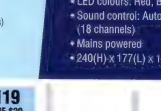
WITH NFC® & BLUETOOTH® TECHNOLOGY

XC-5209

Listen to your favourite music anywhere. Connect to any NFC®-enabled device effortlessly with a single touch and stream music wirelessly up to 10m via Bluetooth®. Supplied with 3.5mm Aux-in and USB charge cables. Up to 5 hours playback time at max volume.

- Microphone and hands-free calling support
- 165(L) x 65(H) x 35(W)mm

$119
SAVE $20



HDMI Display Receiver

AR-1914 **WAS $139**

Turn your HDTV into a Smart TV! Stream videos, music and photos wirelessly from your computer or DLNA enabled Android Smartphone or Tablet to your TV. Connect this smart unit using HDMI (sold separately) to your TV and you can access and control your media instantly.

- Doubles as a Wi-Fi router
- Supplied with software and power adaptor

$169

2.4GHz Digital HDMI AV Sender/Receiver

AR-1871

This value-for-money unit allows you to transmit high definition 1080p audio and video signals from your HD equipment to your HDTV or HD monitor up to 100m away. With the built-in IR receiver/extender, you can also use your remote to control the source from another room. Power supplies included.

- Up to 1080p output resolution
- 2 x 1m HDMI leads included
- 151(L) x 116(W) x 26(H)mm

Mini-D 2 x 10W Class-D Amplifier Kit

SILICON CHIP MAG SEPT 2014 KC-5530

$49.95

This amplifier can deliver more than 10W per channel or 30W mono. Features on-board volume control, low-power shutdown mode and over-temp/current protection. Kit includes double sided, solder-masked and screen-printed PCB, and ALL SMD components pre-soldered to the PCB. Heatsink not required!

- Powered from 8 - 25VDC
- PCB: 85 x 46mm

3.2" LCD Touchscreen Display Kit for Arduino

XC-4280

$119

Add an interactive touchscreen display to your existing Arduino projects. Draw lines, shapes, text, display images, play sound and log data to microSD card. Includes LCD display, 4D Arduino Adaptor Shield, 5-way interface cable and USB programming adaptor with pre-loaded software.

- Operating voltage: 4.5 ~ 5.5VDC
- Screen display area: 64.8 x 48.6mm
- Screen resolution: 240 x 320 pixels
- 65K True to life colours

WE ARE MOVING!

128 MUSGRAVE STREET, ROCKHAMPTON QUEENSLAND 4701 PH: 1800 022 888

Wireless 1080p HDMI Sender Kit

AR-1912

$249

Transmit high definition 1080p audio/video signals from your HD equipment (DVD player, Blu-ray™, etc.) to a HDTV/monitor up to 35m away. This unit uses 5.15GHz - 5.82GHz digital frequency ranges to avoid interference. Built-in IR remote extender.

- Up to 35m clear line of sight transmission range

FREE 1.5M HDMI LEAD FOR REWARDS CARD HOLDERS

WV-7915 Valid with purchase of AR-1912

WV-7915 VALUED AT $19.95.

WIRED CONNECTIVITY UP TO 20 METRES

High Quality AV Leads

HDMI Leads with Built-in Amplifier

10M WQ-7430 **$79.95**
15M WQ-7432 **$99**
20M WQ-7434 **$129**

FROM $79.95

Fibre Optic Leads

1M WQ-7301 **$14.95**
3M WQ-7302 **$24.95**
5M WQ-7303 **$39.95**

FROM $14.95

SMA Coaxial Leads

1M WC-7800 **$17.95**
3M WC-7802 **$29.95**
5M WC-7804 **$39.95**

FROM $17.95

WIRED CONNECTIVITY UP TO 100 METRES

FROM $64.95

HDMI Extenders Over Cat5e/6

Extend your HDMI signal using Cat5e/6 cable. Use your remote in either location with the built-in infrared transmitter.

30M* WITH 2 X CAT5E/6
AC-1730 **$64.95** (Shown)

50M* WITH 1 X CAT5E/6 AC-1732 **$139**

*Depending on cable used and resolution. See website for details.

$159

HDMI Extender Over TCP/IP

AC-1680

Utilises the TCP/IP protocol to extend a HDMI source up to 100m away over a common Cat5e/6 cable. Ideal for setting up multiple displays over long distances.

- Up to 1080p resolution
- IR repeater function
- Power supplies included

EXTRA RECEIVER AC-1701 **$79**

CAT5e CABLES

Cat5e Blue Patch Leads

5M YN-8204 **$8.95**
10M YN-8205 **$14.95**
15M YN-8206 **$21.95**
20M YN-8207 **$24.95**

Other colours in various lengths also available. See website for details.

FROM $8.95

$32.95

Cat5e Solid Core Cable

WB-2023
30m Pack.

WIRED CONNECTIVITY UP TO 300 METRES

$89

Composite AV Extender Balun over Cat5

QC-3681

Transmit crystal-clear audio and video signals over long distances via economical Cat5 cable. Ideal for extending the range of your remote control. The signals can be transmitted up to 300 metres on UTP.

SPARE IR RECEIVER AR-1819 **$19.95**

$119

VGA Extender over Cat5

AC-1671

Transmits VGA and audio signals across a standard CAT5 cable for distances up to 300 metres. Suitable for VGA cable runs through existing wiring in a wall or ceiling. Supplied as a sender and receiver pair with pluggacks included.

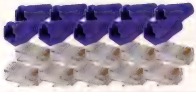
- Supports up to 1920x1200 resolution

BUILD YOUR OWN CAT6 ETHERNET CABLES

Value-for-money bundle pack to help you customise the Ethernet cable to your preferred length. **Cables sold separately.**

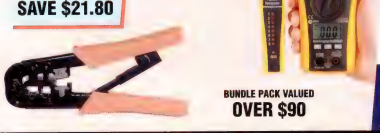
ETHERNET INSTALLATION KIT

RJ45 BOOTS PKT 10	PM-1441 **$4.95**
RJ45 CAT6 CONNECTOR PKT 10	PP-1447 **$13.95**
RJ45 WATERPROOF HOUSING	PS-4064 **$17.95**
6P/8P RATCHET CRIMP TOOL	TH-1935 **$19.95**
MULTI-NETWORK CABLE TESTER	XC-5076 **$39.95**



ETHERNET INSTALLATION KIT $74.95

SAVE $21.80



BUNDLE PACK VALUED OVER $90

$1.65/m

Cat6 Solid Core UTP Cable

WB-2030

ALSO SOLD IN 100M ROLL

REWARDS CARD HOLDERS OFFER: Bulk roll discounts for selected cables. Join now & ask us how.

Composite AV to HDMI Converter

AC-1722

Use this unit to enable old devices such as Sega master systems, DVRs, or VHS players to playback video/audio on more modern HDMI equipped displays. Power supply included.

ALSO AVAILABLE:

HDMI TO COMPOSITE AV CONVERTER AC-1720 **$99**

WATCH ALL YOUR CRICKET, TENNIS OR SOCCER GAMES IN HIGH DEFINITION!

$74.95

3G SDI to HDMI Converter

AC-1727

These units allow HDMI equipped TVs and PC monitors to playback uncompressed 2.970Gbps digital footage from cameras supporting this format. To transmit HDMI over long distances, use AC-1729 as the transmitter with AC-1727 as the receiver.

ALSO AVAILABLE:

HDMI TO 3G SDI CONVERTER AC-1729 **$99.95**

$99.95

$23.95

MHL to HDMI Converter

WITH 11 PIN SAMSUNG® ADAPTOR

WQ-7424

Connect Android Smartphone/tablet devices with MHL (Mobile High-Definition Link) to a HDMI equipped HDTV to view full 1080p video or mirror everything on the device. Supplied with 11 pin micro-B adaptor.

- Requires USB Power

HDMI SPLITTERS & SWITCHERS

FROM $54.95

HDMI Splitter

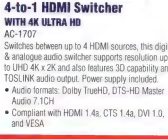
WITH 4K ULTRA HD

Ideal for professional presentations, these units distribute a HDMI source to multiple HDMI displays simultaneously. Power supply included.

- HDMI 1.4 compliant
- Supports 4K UHD, 3D video, Dolby-AC3, DSD audio and more

2 PORT AC-1710 **$54.95** (Shown)

4 PORT AC-1712 **$99.95**



$94.95

4-to-1 HDMI Switcher

WITH 4K ULTRA HD

AC-1707

Switches between up to 4 HDMI sources, this digital & analogue audio switcher supports resolution up to UHD 4K x 2K and also features 3D capability and TOSLINK audio output. Power supply included.

- Audio formats: Dolby TrueHD, DTS-HD Master Audio 7.1CH
- Compliant with HDMI 1.4a, CTS 1.4a, DVI 1.0, and VESA

$99 SAVE $20

4-to-2 HDMI Switcher

WITH 4K ULTRA HD

AC-1714 **WAS $119**

Distribute up to four HDMI sources to 2 displays simultaneously with minimal interruption. IR remote control included.

- Supports resolution up to UHD 4K x 2K and 3D
- DTS digital, Dolby Digital, DTS-HD and Dolby TRUE HD

FROM $24.95

Converter Leads to HDMI Sockets

MINI DVI PLUG 300mm WQ-7423 **$24.95**

DISPLAY PORT PLUG 150mm WQ-7422 **$29.95** (Shown)

$34.95

2m HDMI Type A Plug to Type D "Micro" Plug Lead

WQ-7911

HDMI Type A Plug to Micro-D Plug.

IR & AV EXTENDERS

$14.95

Infrared Panel Mount Receiver

AR-1829

Used for creating a clean, flush mounted IR receiver. Simply screw the thread into the wall and connect the 3.5mm plug to the source device. 3m cable.

- Mounting hole: 13mm
- 28(L) x 17(H)mm

$59.95

4 Channel Compact Infrared Extender Kit

AR-1828

Control Blu-Ray players, set-top boxes, and other home theatre/audio equipment even if they're hidden behind cabinet walls or other types of enclosures. Allows you to control up to 4 devices without interference. *See website for details.*

$39.95 SAVE $10

4-Way AV Stereo Amplifier

AC-1646 **WAS $49.95**

Designed to split a stereo AV signal across 4 channels without loss of image or sound quality. You can wire any room where you would like to access audio and video from a central source. Mains plugpack included.

- Also records up to four sources simultaneously

EARN A POINT FOR EVERY DOLLAR SPENT AT ANY JAYCAR COMPANY STORE* & BE REWARDED WITH A $25 REWARDS CASH CARD ONCE YOU REACH 500 POINTS! **Conditions apply. See website for T&Cs*

REGISTER ONLINE TODAY BY VISITING:

www.jaycar.com.au/rewards

MULTIMEDIA ADAPTORS & WALLPLATES

$5.95

TOSLINK Female Optical to 3.5MM Male Adaptor

PA-3574

TOSLINK Female to Optical 3.5mm Male.

$9.95

Micro HDMI Plug to HDMI Socket Adaptor

PA-3649

Micro HDMI Plug to HDMI Socket.

$14.95

DVI - I Monitor Adaptor

PA-0896

DVI Female to Female.

TECH TIP!

Jack Plug - also known as a phone plug (US) or TRS (tip, ring, sleeve). Available as mono or stereo versions in several common diameters:

- 2.5mm - Once used as a mono earphone plug but now has multichannel functions.
- 3.5mm - The stereo version is widely found on headphones used with portable audio such as MP3 players. The mono version is occasionally used as a DC power connector.
- 6.5mm - The stereo version is often used on Hi-Fi headphones. The 6.5mm (or 1/4" phone plug) was originally used for manual telephone switchboards particularly the 'Sylvester' type. The mono version is used on guitar & microphone leads.

$29.95

Multimedia Wallplate

HDMI, VGA, PC AUDIO AND COMPOSITE VIDEO

PT-0475

Give your media station or projector installation a neat finish with this handy multimedia wallplate. All connections are double-sided for easy installation.

- Standard GPO mount wallplate with concealed screws
- 150mm flylead behind plate on HDMI connection

FREE 180° HDMI ADAPTOR FOR REWARDS CARD HOLDERS PA-3647

PA-3647 VALUED AT $12.95.

DOUBLE POINTS* FOR REWARDS CARD HOLDERS

*Valid for purchase of LT-3181, LT-3182, LT-3136, LT-3275 or LT-3251.

FROM $39.95

TV WALL BRACKETS

Suitable for Plasma/LCD/LED TVs from 23"-60", these heavy duty brackets features solid steel construction, safety lock for security (CW-2822 and CW-2826 only) and are VESA standard compliant.

Anti-Theft Lock Brackets

23" TO 37" CW-2826 **$39.95** (Shown)

32" TO 60" CW-2822 **$89.95**

180° Swivel Brackets

23" TO 37" CW-2829 **$109**

32" TO 60" CW-2825 **$149**

$44.95 DOUBLE POINTS

43 Element UHF TV Antenna

LT-3181

Don't miss a moment of the Summer TV. Suitable for medium signal reception areas.

- Receives Bands 4 and 5
- 13dB gain
- 1234mm long

ALSO AVAILABLE:

91 ELEMENT UHF TV ANTENNA For deep fringe areas. LT-3182 **$89.95 DOUBLE POINTS**

$69.95 DOUBLE POINTS

UHF Phased Array TV Antenna

RECEIVES BANDS 4 AND 5 LT-3138

This wideband phased array antenna suits analogue or digital TV and is ideal for fringe areas, where ghosting is a problem.

- Receives Bands 4 and 5
- UHF channels - 21 to 69 (27 to 62 in NZ)
- 840(L) x 540(W)mm

$49.95 DOUBLE POINTS

UHF/VHF Digital TV Masthead Amplifier

LT-3275

Connect a separate UHF & VHF, or a combination UHF/VHF antenna to this amplifier for excellent signal amplification. Suitable for analogue, digital, and HDTV signals.

- Supplied with AC power injector and F-type to PAL adaptors
- Input gain: UHF 26dB, VHF 18dB
- 125(W) x 102(H) x 45(D)mm

$99.95 DOUBLE POINTS

Kingray VHF/UHF Masthead Amplifier

WITH LTE/4G FILTERS LT-3251

With a large chunk of the Australian TV broadcast spectrum being reallocated for the next generation 4G/LTE mobile phone service, this unit adds a switchable filter to protect against the potential issues with existing TV reception equipment. Supplied with mains adaptor.

- Frequency range: VHF 44-230MHz, UHF 520-860MHz
- Gain control: VHF 16-12dB, UHF 15dB

$99

Digital Indoor/Outdoor Antenna

LT-3137

This versatile unit provides you with high quality clear digital reception with minimal footprint. The panel can be mounted to the wall, or clamped to a pole. Power supply included.

- VHF: 174 - 230MHz
- UHF: 470 - 862MHz
- 10dB antenna gain, 40dB total gain
- 502(L) x 235(W) x 76(H)mm

TV ANTENNA ACCESSORIES

$4.50

Indoor TV Balun

LT-3022

This 75 Ohm to 300 Ohm balun allows connection of any 75 Ohm output (video, TV games, etc) to a TV with an older style 300 Ohm input.

ALSO AVAILABLE:

OUTDOOR 300 OHM TO 75 OHM BALUN LT-3028 **$4.95**

$24.95

Adjustable Antenna Mount Bracket

LT-3205

Ideal for antenna installations with less traditional bargeboards. The base allows for an adjustable angle and contains a mast 1.5mm thick.

- Supplied with mounting hardware
- 520mm long

$34.95

12V Masthead Amp Power Injector

LT-3259

An easy solution to powering a masthead amp on a caravan, RV, camper trailer etc. It plugs into a cigarette lighter/12V power socket and feeds power for a masthead amplifier.

- Suitable with LT-3251 UHF/VHF masthead amplifier

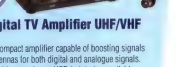
$39.95

Digital TV Signal Strength Meter

LT-3332

Take the guesswork out of installing and tuning your new TV antenna. Connect the pocket sized DVB-T signal strength meter and adjust the angle of your digital TV antenna. Adapters included.

- LED indicator
- Requires 1 x 9V battery
- Frequency range: 40-862MHz



$24.95

Indoor Digital TV Amplifier UHF/VHF

LT-3281

A portable and compact amplifier capable of boosting signals to indoor TV antennas for both digital and analogue signals. It can be powered from mains or USB (mini plug available separately) and features manual UHF/VHF gain adjustors to give you greater control over your signal. Standard PAL connections.

- VHF Frequency: 45 - 230MHz
- UHF Frequency: 470 - 862MHz
- 100(L) x 60(W) x 27(H)mm

BUILD YOUR OWN COAXIAL CABLES

REWARDS CARD HOLDERS OFFER:

Bulk roll discounts for selected cables. Join now & ask us how.

FROM 95¢

PP-0641

F-59 Plugs

F59 connectors suitable for all new TV installations.

F-59 COAX PLUG	PP-0641 **$0.95**
F-59 CRIMP PLUG	PP-0643 **$1.25**
F-59 SCREW-ON PLUG	PP-0638 **$1.45**
F-59 WATERPROOF PLUG	Foxtel Approved PP-0708 **$1.95**
F-59 CRIMPLESS PLUG	PP-0671 **$2.95**

ALSO SOLD IN 100M ROLL

FROM $1.20/m

RG6 Quad Shield 75 Ohm Coaxial Cable

High quality 18AWG coaxial cables ideal for RF signalling in satellite dishes, cable boxes or TV aerials.

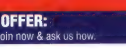
- Foxtel approved

QUALITY VALUE-FOR-MONEY

WB-2006 **$1.20/m**

PROFESSIONAL BELDEN BRAND

WB-2009 **$1.80/m**



$19.95

Rotary Coaxial Stripper

TH-1820

Handy stripper that will strip the outside jacket and inner conductor in one operation. Simply rotate the stripper clockwise around the cable 3 to 6 times. A quality stripper suited to installers.

- Suitable for RG58/59/62/6 and 3C2V 75 ohm cable

$39.95

Ratchet Crimping Tool for F-Type Connectors

TH-1831

A strong, heavy duty tool for crimping F-Type CATV connectors onto RG6 or RG59 coax cable. Ideal for cable TV or RF distributions system installers.

- Secure ratchet mechanism

FROM $9.95

High Quality Microphones

Available in 6.5mm or XLR models, these unidirectional microphones are ideal for all events. Cables included.

6.5MM DYNAMIC AM-4190 **$9.95**

6.5MM PROFESSIONAL AM-4099 **$29.95**

XLR DYNAMIC AM-4192 **$14.95** (Shown)

XLR PROFESSIONAL AM-4096 **$39.95**

Compact 8" Active PA Amplifier

CS-2482

This ultra-compact, powerful and lightweight active PA speaker delivers superb audio clarity and power needed for your next event. Rugged case and highly portable. It has RCA line level, XLR and 6.5mm microphone inputs and also features volume, bass and treble controls. Mains powered.

- 80WRMS
- 380(H) x 220(W) x 195(D)mm
- Weighs only 7.2kg

NEW $149

19" RACK MOUNT CABINETS & ACCESSORIES

FROM $199

SAVE UP TO $40

Swing Frame Rack Mount Enclosures

These solid steel powder coated cabinets allow you to access the rear of your rack system for maintenance or easier installation. Tempered glass doors and locking panels all round.

6U HB-5180 **WAS $219 NOW $199 SAVE $20**

12U HB-5182 **WAS $299 NOW $259 SAVE $40** (Shown)

FROM $49

CS-2477

FROM $69.95

2-Way Indoor/Outdoor Speakers

Add quality surround sound to your indoor or outdoor areas around the workshop, patio or any room. These 2-way weather resistant speakers are made of heavy duty ABS plastic to suit outdoor climate. Mounts vertically or horizontally for perfect sound projection.Sold as a pair.

4" 25WRMS CS-2475 **$69.95** **6.5" 40WRMS** CS-2477 **$99**

5" 30WRMS CS-2476 **$79.95** **8" 50WRMS** CS-2478 **$149**

$89.95

SAVE $10

AC3 and DTS Digital to Analogue Audio Converter

AC-1634 **WAS $99**

Accepts input via RCA coaxial, 2 x SPDIF, or 3.5mm stereo audio and output any of them to 5.1 channel analogue (6 x RCA). For audio enthusiasts who demand highest level of conversion.

- 24-bit audio DSP
- Supports Dolby Digital

NEW

$179

2 x 75WRMS Class D Amplifier AA-0505

Extremely compact and powerful amplifier for its size! Designed to create efficient and high quality audio amplification by using the built-in digital signal processor. It features a volume control and on/off switch on the front panel. On the back the line-level RCA inputs and insulated speaker terminals, along with a DC socket for power. Supplied with AC power adaptor, power lead and a stereo 3.5mm plug to RCA plugs adaptor lead.

- 55WRMS @ 4 Ohm; 30WRMS @8Ohm
- Signal to noise ratio: 90dB
- 165(L) x 95(L) x 30(H)mm

FROM $199

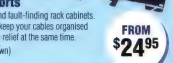
Dual Channel Bridged Rack Mount Amplifiers

Very cost-effective solution for a pro audio application. These versatile rack mount amplifiers can be run as dual channel; stereo or bridged to suit a wide variety of applications. Solid aluminium chassis and front panels. Fan cooled.

- Separate level controls for each channel
- Clipping and overload protection indicator LEDs
- 2U rack mount / 3U subwoofer amplifier

200WRMS AA-0477 **$199** (Shown)

400WRMS AA-0479 **$299**



FROM $24.95

Rack Cable Supports

Take the pain out of wiring and fault-finding rack cabinets. These high quality supports keep your cables organised and neat, and provides strain relief at the same time.

1U HB-5430 **$24.95** (Shown)

2U HB-5432 **$29.95**

6-Way Power Distribution Unit

WITH SURGE & OVERLOAD PROTECTION

MS-4094 **WAS $69.95**

Power up to six components in your rack setup. The board has 6 conventional 240V outlets and fits any standard 19" rack.

- 1U rack space
- Lead length:1.6m
- 482(W) x 63(H) x 45(D)mm

$59.95

SAVE $10

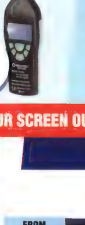
Digital Sound Level Meter

GM-1589

Featuring a wide dynamic range from 30 to 130dB, this unit can measure both A and C weightings and can have fast or slow responses to get an 'ambient' reading or a short noise. Features data hold and min/max functions. Supplied with carry case, wind sock, battery and tripod mount.

- 3.5 digit display
- 30 to 130dB

ALSO AVAILABLE: PROFESSIONAL SOUND LEVEL METER WITH CALIBRATOR QM-1592 **$399**

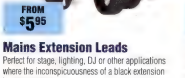


$99

EXTEND YOUR ENTERTAINMENT AREA ... EVEN TAKE YOUR SCREEN OUTDOORS!

REWARDS CARD HOLDERS OFFER:

Bulk roll discounts for selected cables. Join now & ask us how.



FROM $5.95

Mains Extension Leads

Perfect for stage, lighting, DJ or other applications where the inconspicuousness of a black extension lead is required.

- Rated to 10A max

Also available in white. See website for details.

2M PS-4152 **$5.95** (Shown)

5M PS-4155 **$9.95**

10M PS-4157 **$14.95**

FROM $17.95

Dri-Box Weatherproof Power Connection Box

Keeps outdoor mains connections safe and dry. Place the mains connection in the box to seal them from rain, dust, or grime. Features a rubber gasket and openings to run your cables from.

SMALL 2-WAY HB-6175 **$17.95**

LARGE 5-WAY HB-6177 **$24.95**

FROM $24.95

2-Core Speakon Audio Leads

Speakon connectors are now the standard for PA and sound reinforcement applications. Excellent ready-made cable assemblies ideal for building or installing a system.

5M WA-7100 **$24.95** (Shown)

10M WA-7102 **$34.95**

FROM $0.90/m

Heavy Duty Speaker Cables

Extra heavy duty figure-8 OFC speaker cables suitable for speaker systems above 150W.

24/0.2MM WB-1708 **$0.90/m**

41/0.2MM WB-1710 **$1.75/m**

79/0.2MM WB-1712 **$2.50/m**

ALSO SOLD IN 100M ROLL

"Condura" Style DC Rocker Switches

Superb looking rocker switches that you see in 70-100ft luxury motor cruisers. All switches come with double-LED illumination, a standard rocker cover and a standard range of decals to customise the switch to your application. Rated 20A @12V, 10A @24V

Typical decals include: windscreen wipers, horn, heater & many more.

See website for compatible laser-etched covers.

WHITE SK-0910 **$12.95** (Shown)
RED SK-0912 **$12.95**
BLUE SK-0914 **$12.95**
AMBER SK-0916 **$12.95**

4 FOR $40
SAVE $11.80

Marine Grade 10A Cigarette Power Sockets

High quality cigarette power sockets rated up to 10A. Supplied with brackets for flush and surface mounting.

- Connects via 6.3mm spade terminals
- Includes under dash bracket (PS-2020 only)

SINGLE PS-2020 **$14.95**
DUAL PS-2022 **$19.95**
SINGLE WITH LED VOLTMETER PS-2024 **$27.95**
SINGLE WITH 2 USB PORTS (1A + 2.1A) PS-2026 **$29.95** (Shown)

FROM $14.95

90W Automatic Car Laptop Power Supply

MP-3323

NEW $59.95

High efficiency, ultra-slim power supply with automatic output for smaller laptops that connects to your car's cigarette lighter socket. This unit features a 2.4A USB port and LCD display that shows you the voltage being delivered. Includes 13 interchangeable plugs to suit most laptops. *See website for compatible models.*

- Input voltage: 12VDC
- Output voltages: 14-24VDC / 5VDC (USB)
- Output current: 6A / 2.4A (USB)
- Size: 64(L) x 50(W) x 17(H)mm
- Weighs only 72g

DOUBLE POINTS* ON SOLAR ESSENTIALS FOR REWARDS CARD HOLDERS

**valid for purchases of ZM-9150, ZM-9152, ZM-9154, MP-3129, MP-3723 or MP-3724*

$99

Weatherproof Commercial Grade Infrared Beam LA-5179

Detects when a person or object crosses a boundary or entrance way. Features a weatherproof (IP66) casing with an anti-fog sensor window making it suitable for use outdoors and in dusty or damp environments.

- Up to 15m range
- Adjustable vertical beam angle
- Input voltage: 12 to 250V AC or DC
- 122(H) x 62(D) x 61(W)mm

ALSO AVAILABLE:
EXTENSION BUZZER LA-5188 **$34.95**
COUNTER MODULE LA-5197 **$34.95**

8 Zone Wireless Alarm Kit LA-5145

$149

Everything you need to get a basic wireless system set up in your home! Includes a key fob remote control, backlit LCD control panel, PIR sensor and two reed switches.

See website for spare accessories.

- Back-up battery
- 210(L) x 113(W) x 127(H)mm

$149

High Grade CCD Cameras with IR Illumination

Available as an indoor dome or weatherproof outdoor model, both feature 1/3" CCD sensors and built-in IR LEDs so you can be sure to capture good quality video day or night. 12VDC.

- 650TV lines

BULLET CAMERA 145(L) x 85(H) x 68(W)mm QC-8634 **$149**
DOME CAMERA 120(Dia) x 90(H)mm QC-8636 **$149**

$279

1/3" Bullet Mount IP Camera - 720p

QC-8638

Connect this IP66 rated bullet camera to your Ethernet switch and access it via the internet or your local intranet. This professional grade IP camera provides high definition 720p video resolution, in a weatherproof housing suitable for mounting under eaves, with IR LEDs for night time illumination. Power supply included. 12VDC. *See website for details.*

- 1/3" 1.3MP Aptina CMOS
- 64(Dia) x 145(H)mm

SOLAR ESSENTIALS FOR YOUR OUTDOOR ENTERTAINMENT

Semi-Flexible Solar Panels

These 12V flexible solar panels offer performance at an affordable price. No heavy rigid frame makes them extremely light and portable. All units have a fully sealed terminal box with approx 900mm of power cable: 12V

18W ZM-9150 **$89.95**
40W ZM-9152 **$179**
100W ZM-9154 **$399** (Shown)

FROM $89.95 DOUBLE POINTS

Solar Charge Controllers

Efficiently charges a vast selection of batteries from a wide range of solar panels. This microprocessor controlled unit is capable of handling all of your solar charging requirements and protect your battery. It has an array of features including adjustable charging voltage, automatic dusk-till-dawn on/off, overload protection, etc.. *See our website for details.*

- 3-stage charge modes
- LCD display shows system status

12V 20A MP-3129 **$149**
12V 30A MP-3722 **$179**
24V 20A MP-3724 **$159** (Shown)

FROM $149 DOUBLE POINTS

HOT POWER PRODUCTS FOR YOUR ADVENTURES

FROM $24.95

SLA Battery Boxes

Designed to suit batteries or your standard car battery. Perfect for mounting in your boat, trailer or caravan. Includes mounting clamps and lid strap.

HB-8500 includes high current bolt terminals and marine grade cigarette power sockets.

BATTERY BOX TO SUIT 40AH HB-8100 **$24.95**
BATTERY BOX TO SUIT 100AH HB-8102 **$29.95**
BATTERY POWER BOX TO SUIT 100AH HB-8500 **$89.95** (Shown)

FROM $129

Deep-Cycle Gel Batteries

These are genuine deep-cycle batteries that can be operated and charged in any position. Leakproof and completely sealed. Ideal for solar power, 4WD, camping, etc. 12VDC

26AH SB-1698 **$129**
38AH SB-1699 **$189**
100AH SB-1695 **$379** (Shown)

Note: 100Ah not stocked in all stores. Call ahead to check stock.

High Power 4-Stage 240V Battery Chargers

Tough mains powered high power battery chargers designed to quickly recharge 12V lead-acid batteries. Smart 4-stage charging to ensure battery life is maintained by monitoring and charging the batteries safely, resulting in a charger that is safe to leave connected indefinitely. Over-charging and ouput short-circuit protected. Wall mountable.

- Bulk/Absorption: 14.2VDC / 14.6VDC / 14.6VDC
- Float charging: 13.2VDC / 13.5VDC / 13.8VDC
- Efficiency: Up to 88%

15A MB-3710 **$219** (Shown)
40A MB-3715 **$399**

FROM $219

10% OFF* THESE DMMs FOR REWARDS CARD HOLDERS

Valid for purchase of QM-1523, QM-1551 or QM-1576

$14.95

Cat II DMM

VALUE-FOR-MONEY
QM-1523
Quality DMM with 15mm high digits and backlit LCD for easy reference. Carry pouch included.
- Cat II 600V, 2000 count
- AC/DC voltages up to 500V
- AC/DC current up to 10A
- Resistance measurement, transistor test, data hold
- 145(L) x 65(W) x 35(H)mm

$59.95

Cat III True RMS Autoranging DMM

QM-1551
A powerful true RMS multimeter that includes non-contact voltage testing, backlit LCD, and a carrying pouch.
- Cat III 600V, 4000 count
- AC/DC voltages up to 600V
- AC/DC current up to 10A
- Temperature, resistance, capacitance, and more
- True RMS for accurate readings
- Autoranging, continuity, diode check
- 138(L) x 66(W) x 37(D)mm

$219

Cat IV True RMS DMM

WITH SMARTPHONE APP QM-1576
View live measurements, trend graphs, data log, and email your results or upload them to the Cloud – all from your Smartphone!
- CAT IV 600V, 40000 count
- AC/DC voltages up to 1000V
- AC/DC current up to 10A
- Resistance, capacitance, frequency etc.
- Bluetooth® and PC connectivity
- Data hold/storage, triple LCD display
- 182(L) x 82(W) x 55(D)mm

$179
SAVE $20

1MHz Handheld Function Generator

QT-2304 **WAS $199**
A bench top generator in a portable size! Produces sine, square, and triangle waveform signals with output frequency adjustment from 1Hz to 1MHz with maximum amplitude of 8Vpp.
- Backlit LCD
- Sweep modes: Linear/logarithmic, single/bidirectional
- 114(H) x 74(W) x 29(D)mm

$299

60W ESD Safe Solder / Rework Station

TS-1574
Complete solder/desolder station for production and service use. Soldering/rework functions can be operated independently of each other. Suitable for lead-free solder.
- Celsius and Fahrenheit display
- Microprocessor controlled
- 225(L) x 215(W) x155(H)mm

SPARE TIPS ALSO AVAILABLE:
2.5MM SINGLE TIP TS-1575 **$13.95**
4.4MM SINGLE TIP TS-1576 **$13.95**
10X10MM QUAD TIP TS-1577 **$19.95**
15X15MM QUAD TIP TS-1578 **$19.95**

$7.95

Turbo Weld Kit NA-1524

An all-purpose formula that bonds in seconds and easily repairs objects made of metals, timber, ceramics, plastics, glass, rubber and much more.
- Non-toxic, colourless, ultra strong and versatile
- Pack contains 1 x welding powder and 1 x adhesive

Electronic Cleaning Aerosol NA-1004

Non-CFC ozone free propellant ideal to use on delicate electronic, electrical and mechanical assemblies.
- 175g
- Fast drying and high purity

$11.50

FROM $14.95

Braided Hook and Loop Loom Wrap

Wraps around your cables and secures them with hook and loop. 1.5m long. *Cables not included.*

32MM WIDE WH-5654 **$14.95**
51MM WIDE WH-5656 **$17.95**

BUILD YOUR OWN ARDUINO AUDIO SPECTRUM ANALYSER. ASK US HOW.

$39.95

"Eleven" Microcontroller Board for Arduino XC-4210

"Eleven" is based on the Arduino Uno but with improvements. Top spec ATmega328P Microcontroller, independent prototyping area, visible LEDs, and firmly mounted Micro-USB connector to power your Eleven from most cellphone chargers! Includes USB cable and guide sheet. 100% Arduino compatible.

ALSO AVAILABLE:
PROTOSHIELD BASIC XC-4214 **$4.45**

Drink can not included.

FROM $39.95

Large Dot Matrix LED Display Panels for Arduino

This large, bright 512 LED matrix panel has onboard controller circuitry designed to make it easy to use straight from your Arduino board.
- 32 x 16 high brightness blue LEDs on a 10mm pitch
- Viewable over 12 metres away

RED LED DISPLAY XC-4250 **$39.95**
BLUE LED DISPLAY XC-4251 **$89.95** (Shown)

$23.95 ea

Gaffer Tapes

Preferred by the professionals. Leaves no residue behind and sticks to most clean surfaces. 40m roll.

BLACK NM-2812 **$23.95**
SILVER NM-2814 **$23.95**

$49.95

Anti-Static Field Service Foldable Mat TH-1776

Ideal for anyone who repairs or services sensitive electronic equipment.
- 3mm thick, hard wearing faux over dense sponge rubber base
- Mat folds out to approx. 600 x 600mm

ESSENTIALS FOR YOUR ARDUINO PROJECTS

PS-0180

FROM $1.65

High Quality PCB Mount Connectors

Use these connectors with your Arduino project to analyse sound on your computer or device and display the spectrum analysis on the LED matrix.

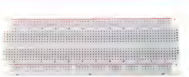
USB TYPE A PLUG	PP-0790 **$2.45**
USB TYPE A SOCKET	PS-0916 **$2.95**
3.5MM STEREO SOCKET	PS-0133 **$1.65**
6.5MM STEREO SOCKET	PS-0180 **$2.95**

FROM $3.95

Mixed 10-Piece Jumper Leads

For use in arduino projects, school experiments, or RC and other hobbyist activities.

PLUG TO SOCKET/SOCKET TO SOCKET 155mm long. WC-6021 **$3.95** (Shown)
PLUG TO PLUG 155mm long. WC-6022 **$3.95**
ALLIGATOR CLIPS HEAVY DUTY 300mm long. WC-6020 **$11.95**



FROM $9.95

Solderless Breadboards

Three sizes of breadboards to suit all your project needs.

300 TERMINAL HOLES PB-8832 **$9.95**
640 TERMINAL HOLES PB-8814 **$19.95** (Shown)
1280 TERMINAL HOLES PB-8816 **$39.95**

$34.95

Light Duty Hook-up Wire Pack - 8 colours

WH-3009
Quality tinned hook-up wire on plastic spools. 8 rolls included, each roll a different colour.
- 25m on each roll

UP TO 75% OFF CLEARANCE STOCK

Listed below are a number of discontinued (or still going) items that we can no longer afford to hold stock. Please ring your local store to check stock.
All these prices are real! Be able to transfer from store to store. **STOCK IS LIMITED, ACT NOW TO AVOID DISAPPOINTMENT. SORRY NO RAINCHECKS**

AUDIO & VIDEO

CAT. NO.	PRODUCT		WAS	NOW	SAVE
CS-2429	12" Active Subwoofer		$199	$159	$40
AX-3586	15" Speaker Protection Grille with Clips	HOT PRICE	$12	$3.95	$8.05
WD-7299	15mm/5mm Fibre Optic Swappable Lead 2m		$14.95	$5.95	$9
AX-3594	8" Speaker Protection Grille with Clips	HOT PRICE	$8	$2.95	$5.05
SL-3423	DMX LED Light Controller 5 Channel		$89.95	$49.95	$40
LT-3057	Fixed Attenuators BNC 12dB	HOT PRICE	$9.95	$2.50	$7.45
LT-3053	Fixed Attenuators BNC 3dB	HOT PRICE	$9.95	$2.50	$7.45
LT-3052	Fixed Attenuators F-Type 3dB	HOT PRICE	$9.95	$2.50	$7.45
LT-3054	Fixed Attenuators F-Type 6dB	HOT PRICE	$9.95	$2.50	$7.45
AC-1615	HDMI Audio Signal Volume Leveller		$89	$59	$30
AC-1641	HDMI Repeater with Infrared Extender		$89	$79.95	$19.05
WC-7744	HDMI Retractable Lead A-Male to D-Male 1.3m	HOT PRICE	$19.95	$9.95	$10
AC-1635	HDMI Stereo Audio Inserter	HOT PRICE	$99	$49.95	$49.05
WA-7109	Speakon Lead Splitter 2-Way		$24.95	$14.95	$10
WQ-7298	Toslink to 3.5mm Fibre Optic Lead 1m		$9.95	$5.95	$4
AC-1596	Toslink to Coaxial Audio Converter		$24.95	$19.95	$5
AC-1616	USB 2.0 Audio Converter	HOT PRICE	$69	$39	$30
GE-4140	USB Cassette Player	HOT PRICE	$49.95	$29.95	$20
AR-1895	Wireless 2.4GHz 15WRMS Stereo Amplifier	HOT PRICE	$99	$49.95	$49.05

AUTO & OUTDOORS

CAT. NO.	PRODUCT		WAS	NOW	SAVE
LA-5262	12V Siren with 10 Sounds and Microphone		$44.95	$37.95	$7
PP-2126	12V/24VDC Car Charger with USB Port		$9.95	$5.95	$4
HM-3086	Battery Clamps 400 Amp Stainless Steel		$9.95	$5.95	$4
SI-3066	Handheld Spotlight 12V 40,000 Candlepower		$9.95	$7.95	$2
AA-2097	Handsfree AUX Mic Lead For Smartphones		$9.95	$7.95	$2
AR-3104	In-Car FM Transmitter Kit with Antenna	HOT PRICE	$39.95	$19.95	$20
SI-3460	Magnetic Torch with Gooseneck 150 Lumens	HOT PRICE	$44.95	$24.95	$20
PP-2140	OBDII (Car Computer) Plug / Memory Saver		$9.95	$5.95	$4
SZ-2070	Power Distribution Block 2-Way Gold Fused		$24.95	$19.95	$5
ST-3312	Solar Chargeable LED Spotlight 140 Lumens		$29.95	$24.95	$5

TEST & TOOLS

CAT. NO.	PRODUCT		WAS	NOW	SAVE
TD-2151	Drill Assistant with User Leveler	HOT PRICE	$19.95	$11.95	$8
QM-7211	Non-Contact Thermometer with Temp Comparison	HOT PRICE	$89	$53.95	$35.05
QC-1903	Oscilloscope Probe Kit 100:1		$59.95	$47.95	$12
WT-5302	SMD DMM Test Leads	HOT PRICE	$9.95	$3.95	$5
DC-3851	Stylus Inspection Camera Suits Smartphones		$149	$119	$30

HARDCORE

CAT. NO.	PRODUCT		WAS	NOW	SAVE
AA-0595	Dimmable Constant Current LED Driver		$12.95	$10.95	$2
AA-0585	Power Supply for 3W Star LEDs		$12.95	$10.95	$2
AA-0580	Power Supply for Loaded LED Star Modules		$12.95	$10.95	$2
AU-5556	Ultrasonic Transducer 50W 40kHz	HOT PRICE	$59.95	$29.95	$30

IT & COMMS

CAT. NO.	PRODUCT		WAS	NOW	SAVE
PL-0940	5 Pin DIN Plug to 6 Pin Mini DIN Socket		$7.95	$4.95	$3
PL-0941	5 Pin DIN Socket to 6 Pin Mini DIN Plug		$7.95	$4.95	$3
CW-2873	LCD Monitor Wall Mount Bracket		$69	$59.95	$9.05
CW-2870	Mounting Arms for Apple® iMac®	HOT PRICE	$89	$52.95	$36.05
WC-7510	RS232 Extension Cable Computer Lead 3m		$19.95	$15.95	$4
WC-7514	RS232 Serial Laplink Cable Computer Lead 1.8m	HOT PRICE	$19.95	$11.95	$8
DC-1052	UHF 75 Channel CB Headset 0.5W		$99	$69.95	$29.05
XC-4691	USB 3.0 Cradle Dock	HOT PRICE	$99	$59.95	$39.05
PA-0926	USB A Socket to USB A Plug Adaptor		$7.95	$5.95	$2
XC-4949	USB KVM & Data Transfer Cable		$49.95	$39.95	$10
WC-7735	USB Retractable Lead A-Plug to A-Plug	HOT PRICE	$14.95	$8.95	$6
WC-7736	USB Retractable Lead A-Plug to Micro B 5M		$14.95	$11.95	$3
CW-2871	Wall Mount Bracket for Apple® & iMac®	HOT PRICE	$79	$47.95	$31.05

POWER & LIGHTING

CAT. NO.	PRODUCT		WAS	NOW	SAVE
ZD-0378	Eoslume 15W Downlight Kit, Neutral White	HOT PRICE	$99	$39.95	$59.05
ZD-0373	Eoslume 15W Downlight Kit, Warm White	HOT PRICE	$99	$39.95	$59.05
ST-3899	GU10 LED Downlight 2W Warm White 4-Pack	HOT PRICE	$149	$69.95	$79.05
ST-3898	GU10 LED Downlight 2W White 4-Pack	HOT PRICE	$149	$69.95	$79.05
ST-3897	GU10 LED Downlight 3 x CREE 2W Warm White	HOT PRICE	$39.95	$19.95	$20
ZD-0458	IP66 Aluminium Backed LED Strip Lights		$19.95	$16.95	$3
MS-6158	IR Controlled Wireless Mains Sockets	HOT PRICE	$26.95	$9.95	$17
ZD-0467	LED Strip Light 6mm Warm White 24V		$14.95	$8.95	$6
ZD-0554	LED Strip Light 11mm Warm White 24V		$19.95	$11.95	$8
ZD-2749	LED Waterproof Bulkhead Light	HOT PRICE	$29.95	$17.95	$12
ST-3264	LED Work Light Low Cost 12V		$29.95	$23.95	$6
MS-4017	Mains Surge Protector with Phone Protection		$6.95	$4.95	$2
MP-3452	Mains Travel USB Adaptor with Interchangeable Plugs		$12.95	$7.95	$5
MP-5157	Spare Wireless Socket for MS-5158	HOT PRICE	$9.95	$4.95	$5
SL-2746	TS Fluoro Lamp Adaptor Kit - 2ft	HOT PRICE	$17.95	$7.95	$10
SL-2748	TS Fluoro Lamp Adaptor Kit - 4ft	HOT PRICE	$19.95	$7.95	$12

SECURITY

CAT. NO.	PRODUCT		WAS	NOW	SAVE
LA-5460	Alarm Kit 2-Zone Wired	HOT PRICE	$59.95	$29.95	$30
QC-8631	Hidden Camera Mirror 600TVL	HOT PRICE	$149	$89.95	$59.05
LA-5368	Intelligent 10 Sector Alarm System		$99	$79.95	$19.05
LA-5156	Intelligent GSM Wireless Alarm System		$299	$219	$80
LA-5073	Intelligent Shock Sensor	HOT PRICE	$34.95	$14.95	$20
QC-8626	Network Mini Dome Camera 2MP		$299	$239	$60
QV-8122	Professional 16 Channel DVR		$899	$729	$170
SL-3232	Rechargeable Emergency Spotlight with PIR	HOT PRICE	$49.95	$29.95	$20
SL-3235	Solar Chargeable Spotlight with Anemometer	HOT PRICE	$109	$59.95	$49.05
QC-3646	Solar Powered 2.4GHz Wireless Camera Kit	HOT PRICE	$199	$119	$80
LA-5174	Solar Wireless PIR Announcer	HOT PRICE	$59.95	$29.95	$30
QC-3735	Video Door Peephole Viewer	HOT PRICE	$225	$129	$96
QC-3644	Wireless DIY Kit with Solar Powered Camera	HOT PRICE	$299	$179	$120

TERMS AND CONDITIONS: REWARDS CARD HOLDERS FREE GIFT, % SAVING DEALS, DOUBLE POINTS & OFFERS requires active Jaycar Rewards Card membership at time of purchase. Refer to website for Rewards Card T&C. **DOUBLE POINTS FOR REWARDS CARD HOLDERS** is for purchase of LT-3187, LT-3182, LT-3138, LT-3251, XM-9150, ZM-9152, ZM-9154, MP-3129, MP-3722, MP-3724. **ETHERNET INSTALLATION KIT BUNDLE DEAL** is for these selected products: PM-1841, PP-1447, PS-4064, TH-1935 & XC-5070.

Australian Capital Territory

Belconnen — Ph (02) 6253 5700
Fyshwick — Ph (02) 6239 1801

New South Wales

Albury — Ph (02) 6021 6788
Alexandria — Ph (02) 9699 4699
Bankstown — Ph (02) 9707 2822
Blacktown — Ph (02) 9678 9669
Bondi Junction — Ph (02) 9369 3899
Brookvale — Ph (02) 9905 4130
Campbelltown — Ph (02) 4625 0775
Castle Hill — Ph (02) 9634 4470
Coffs Harbour — Ph (02) 6651 5238
Croydon — Ph (02) 9799 0402
Dubbo — Ph (02) 6881 8778
Erina — Ph (02) 4365 3433
Ferry Meadow — Ph (02) 4325 0999
Gore Hill — Ph (02) 9439 4799
Hornsby — Ph (02) 9476 6221
Liverpool — Ph (02) 9821 3100
Maitland — Ph (02) 4934 4911
Newcastle — Ph (02) 4968 4722
Penrith — Ph (02) 4721 8337
Port Macquarie — Ph (02) 6581 4476
Rydalmere — Ph (02) 8832 3100
Smithfield NEW — Ph (02) 9604 7411
Sydney City — Ph (02) 9267 1614
Taren Point — Ph (02) 9531 7033
Tuggerah — Ph (02) 4353 5016
Tweed Heads — Ph (07) 5536 4566
Wagga Wagga — Ph (02) 6931 9333
Warners Bay — Ph (02) 4954 8100
Wollongong — Ph (02) 4226 7089

Queensland

Aspley — Ph (07) 3863 0099
Browns Plains — Ph (07) 3800 0877
Caboolture — Ph (07) 5432 3152
Cairns — Ph (07) 4041 6747
Calounda — Ph (07) 5491 1000
Capalaba — Ph (07) 3245 2014
Ipswich — Ph (07) 3282 5800
Labrador — Ph (07) 5537 4295
Mackay WE HAVE MOVED — Ph (07) 4953 0611
Maroochydore — Ph (07) 5479 3311
Mermaid Beach — Ph (07) 5526 6722
NEW Rockhampton WE ARE MOVING — Ph (07) 4926 4166
Townsville — Ph (07) 4772 5022
Strathpine — Ph (07) 3889 6918
Underwood — Ph (07) 3841 3888
Woolloongabba — Ph (07) 3393 0777

Victoria

Cheltenham — Ph (03) 9585 5011
Coburg — Ph (03) 9384 1811
Fentner Gully — Ph (03) 5758 5500
Frankston — Ph (03) 9781 4100
Geelong — Ph (03) 5221 5800
Hallam — Ph (03) 9796 4577
Kew East — Ph (03) 9859 6188
Melbourne City — Ph (03) 9663 2030
Mornington — Ph (03) 5976 3911
Ringwood — Ph (03) 9870 9053
Roxburgh Park — Ph (03) 8339 2042
Shepparton — Ph (03) 5822 4037
Springvale — Ph (03) 9547 1022
Sunshine — Ph (03) 9310 8066
Thomastown — Ph (03) 9465 3333
Werribee — Ph (03) 9741 8951

South Australia

Adelaide — Ph (08) 8231 7355
Clovelly Park — Ph (08) 8276 6901
Elizabeth — Ph (08) 8255 6999
Gepps Cross — Ph (08) 8262 3200
Modbury — Ph (08) 8265 7511
Reynella — Ph (08) 8387 3647

Western Australia

Bunbury NEW — Ph (08) 9721 2868
Joondalup — Ph (08) 9301 0916
Maddington — Ph (08) 9493 4300
Mandurah — Ph (08) 9586 3827
Midland — Ph (08) 9250 0200
Northbridge — Ph (08) 9328 8252
Osborne Park NEW — Ph (08) 9444 9250
Rockingham — Ph (08) 9592 8000

Tasmania

Hobart WE HAVE MOVED — Ph (03) 6272 9555
Launceston — Ph (03) 6334 2777

Northern Territory

Darwin — Ph (08) 8948 4043

Jaycar Electronics
Better, More Technical

YOUR LOCAL JAYCAR STORE

Free Call Orders: 1800 022 888

HEAD OFFICE
320 Victoria Road, Rydalmere NSW 2116
Ph: (02) 8832 3100
Fax: (02) 8832 3169

ONLINE ORDERS
Website: www.jaycar.com.au
Email: techstore@jaycar.com.au

Occasionally there are discontinued items advertised on a special / lower price in this promotional flyer that has limited to nil stock in certain stores, including Jaycar Authorised Stockist. These stores may not have stock of these items and can not order or transfer stock.

Arrival dates of new products in this flyer were confirmed at the time of print but delays sometimes occur. Please ring your local store to check stock details. Savings off Original RRP.
Prices valid from 26 December, 2014 - 23 January, 2015.

PRODUCT SHOWCASE

Microchip's Upgrade Offer

If you currently own a PICkit 2, ICD 2 or PROMATE II, (so-called "legacy" tools which do not support Microchip's newer devices), Microchip is offering a heavily discounted upgrade on their latest tools.

ICD 2, for example, is not compatible with MPLAB X IDE.

This offer also covers older versions of ICD 3 (revision 3 and earlier) and PICkit 3 (revision 2 and earlier).

Until **28th February** you can trade in your old programmers and debuggers too, for a PICkit 3, ICD 3 or PM 3 at 50% off the retail price!

Upgrading is easy: simply download and fill in the form from the landing page, **www.microchip.com/devtool-migration**, then mail the form with the old tool to either of Microchip's US or European Service Centre (addresses are on the form).

You will receive a 50% coupon discount coupon via email, which allows you to purchase the new tool from one of Microchip's participating distributors or from microchipDIRECT.

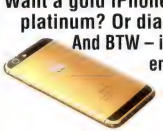
There are just a couple of conditions: the buyer pays shipping charges and any applicable taxes (though buying from Australia should not incur any taxes) and discounts cannot be combined.

WARNING: POTENTIAL FRAUD

Despite checks made by Silicon Chip prior to publication, we have since been advised that the advertisement for "Network Communications" on page 9 of our December 2014 issue is bogus. There is no connection with Network Communications in Queensland. Readers are advised NOT to have any dealings with this advertiser.

This warning also appears on our website, siliconchip.com.au

Want a gold iPhone 6? Or platinum? Or diamond? And BTW – it makes encrypted calls too!



US company Brikk have launched their Lux iPhone 6 Secure, which makes encrypted calls with no communication record, making it the perfect device for anyone whose correspondence may be the target of interception by third parties.

The Lux iPhone 6 Secure models have built-in technology identical to that used to protect telephones used by presidents, government officials, celebrities and corporate executives worldwide.

This allows for 256-bit digital encryption, making it incomprehensible to anyone but the parties involved. Privacy is further guaranteed by the fact that all calls made from the phone are routed through a network of global servers, located in more than ten countries around the world where telephone interception and wire tapping is illegal.

The Lux iPhone 6 Secure is available in standard versions (starting at $US4,995), 24k gold or 950 platinum plated versions (starting at $US9,995), or diamond versions (starting at $US13,895). All models are packaged in a custom Brikk box, complete with a user manual and all standard accessories. Each Lux iPhone 6 Secure by Brikk also comes with a diamond-embedded certificate of authenticity and an exclusive 1-year warranty provided by Brikk and Brikk Service Centers. The Lux iPhone 6 Secure is available at Brikk Authorized Resellers, Brikk stores and through **www.brikk.com**

Spirit's Melbourne 200MB/s SDSL – Faster than NBN!

Melbourne's premier Multi-Dwelling Units are about to receive ultra-fast symmetric upload and download speeds of up to 200Mbps from Spirit.

Spirit Telecom has launched its UFi product which outpaces its competition, including NBN, with a much faster symmetrical service. UFi (meaning Ultra-Fast Internet) sets a new benchmark for Internet services in Australia.

Spirit UFi uses its own in-building network, rather than old copper and comes at a time when download and upload activities of Australians are ever increasing. Spirit customers will have a more consistent Internet experience, with robust service reliability at all hours for frequent sharing activities such as smooth video chatting, great online gaming experience, sharing multimedia files and uploading/downloading large files in backing up using cloud services.

Spirit tested the symmetric speed on its network at College Square in Carlton. Using a sizable sample of customers, the result was a 61% increase in data uploads, compared to the same period in 2014.

Contact:
Spirit Telecom
PO Box 377, Prahran, Vic 3181
Tel: 1300 007 001 **Fax:** 1300 887 813
Website: www.spirit.com.au

Those aren't dirt specs: they're dotLEDs!

Plessey's smallest packaged (1.0 x 0.5mm) dotLEDs have been named one of the Hot 100 products of 2014 by EDN.

The PLW13D003, a white LED in a SMT package, is designed specifically for the demand for ever-smaller LEDs producing highly collimated light and is aimed at the surging wearable electronics market. Made with Plessey's "MaGIC" process (Manufactured on GaN-on Si I/C), they weigh just 0.2mg, have a profile of 0.25mm and deliver up to 0.7 lumens with a 130° viewing angle.

Contact:
Plessey Semiconductors
Tamerton Rd, Rodborough, Plymouth, Devon, UK
Website: www.plesseysemiconductors.com

SERVICEMAN'S LOG

DIY printer repairs can easily go wrong

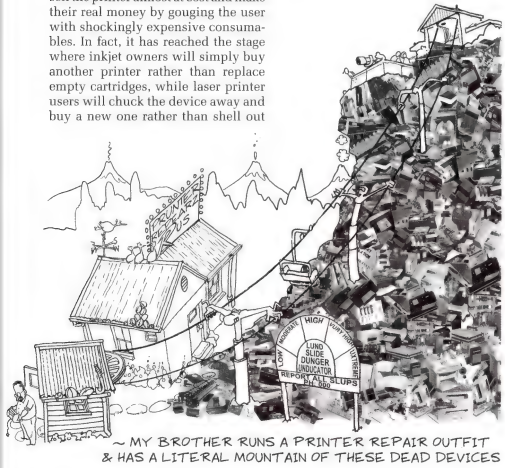
Dave Thompson*

There are lots of traps for the unwary when it comes to fixing printers, especially if you download "printer reset" software from the internet. Want to get the back seat of your car covered in printer ink? It happened to a customer of mine.

One of the first peripherals purchased by most computer owners is a printer. Printers really haven't changed a lot in the past decade, although there have been refinements to the print heads in inkjet type devices and to the drum technology used in laser printers.

What we have seen is the price of printers falling through the floor, usually because printer manufacturers have cottoned on to the fact they can sell the printer almost at cost and make their real money by gouging the user with shockingly expensive consumables. In fact, it has reached the stage where inkjet owners will simply buy another printer rather than replace empty cartridges, while laser printer users will chuck the device away and buy a new one rather than shell out for a new drum and/or toner assembly.

The resulting e-waste is almost criminal and it is with good reason that many countries now force manufacturers to run their own recycling schemes. In reality, this sometimes involves sending containers full of dead printers to China or India where the locals use crude methods to strip anything valuable from them. This would be fine except that these processes often result in ecological damage such as contaminated water supplies and poisoned soil, something that doesn't sit easily with many of us.



~ MY BROTHER RUNS A PRINTER REPAIR OUTFIT & HAS A LITERAL MOUNTAIN OF THESE DEAD DEVICES

My brother runs a printer repair outfit and has a literal mountain of these dead devices. Some he keeps for parts and some he keeps because it seems criminal to throw them away. One problem he faces is that sourcing new spare parts for printers can be a lesson in abject frustration, so it's not only the prohibitive cost of consumables that causes these devices to be discarded.

For example, one particular multifunction model has a propensity to break a Mylar ribbon cable that's used to connect a couple of moving parts. This ribbon cannot be purchased as a spare part, meaning that this $200 printer is rendered useless for the sake of a part that would cost no more than a few dollars and could be easily replaced.

That's why my brother keeps dead machines; by scrounging parts from these old carcasses, he can often get a customer up and running again, thereby saving them the hassle of buying a new machine and disposing of the old one.

Of course, the main flaw in this scheme is that many dead machines of a particular model are junked for the same reason. This means that they are often useless for parts unless it is something else that has failed in the client's machine. All in all, it's a difficult situation and if I had the answer, I'd share it.

Against that background, it's no wonder that many people with malfunctioning printers just toss them and buy a new one. All we can do is hope that when someone says they will correctly dispose of an item, they actually do break it down and dispose of it sensibly.

However, some people do choose the repair option. Whether it's because they are like me and think that keeping a good printer going is better than chucking it out or they just deem it

more sensible to repair rather than replace, we still get printers in for repair.

Faulty inkjet printer

Problems with ink are among the most common faults reported by end users. In one recent case, a customer brought in an inkjet printer that wasn't very old but had done a fair amount of work. Unfortunately, it had covered portions of the back seat of his car in printer ink and from experience that stuff doesn't come off very easily.

In some ways, it was poetic justice because this guy had been using information gleaned from so-called experts on the internet in an effort to fix it himself. In the process, he had bypassed some built-in safeguards, resulting in the soiled back seat.

As you know, I'm all for people having a go at doing things themselves in many cases but there is a right way and a wrong way of going about it. Exercising due diligence and finding out all there is to know about the device before jumping in and trying all manner of repairs is one of the most important steps in the DIY process.

Extracting the correct information out of all the misinformation posted on the web by so-called "experts" is critical and simply chucking every "fix" you find at a problem can easily end up making things worse. Or make a mess of the back seat of your car!

In this case, the customer's problems began after his printer had output a certain number of pages and had then begun indicating an error. And by that I don't mean that it indicated what was wrong on the tiny LCD panel. Instead, the error was indicated by a flashing red LED and the printer simply stopped printing.

Since the flashing LED is a "catch-all" error indicator, it is up to the user or technician to deduce what the real problem is. While some printers will keep working in an error state, it depends on the problem and most will remain inoperable until something has been done to resolve and clear the fault.

Waste ink pads

That's where Google came in. In an effort to fix the problem himself, this guy had done a quick search and downloaded a small software tool that's used by printer technicians to reset errors and manipulate the various sensors and counters most printers use. What he didn't realise was that, in this case, the error condition had been tripped because the waste ink pads in his printer were full, meaning that they required cleaning or replacement.

Most people, including my client, don't realise that the majority of inkjet printers have these waste ink pads tucked away inside the printer. They vary in shape and size but are typically made of dense felt-type material, ideal for soaking up any excess ink produced by the print-head.

This excess ink is usually produced by the head cleaning process but can also occur if the wrong ink has been used in self-fillable or non-factory refill cartridges. It may only be a tiny drop at a time but the waste ink pads eventually become saturated and if they are not cleaned or replaced, the ink ends up spilling into the body of the printer and then out through any gap or hole it finds in the case.

To prevent this from happening, printers with waste ink pads often have a sensor mounted in the waste-ink reservoir to detect when the level gets too high. Alternatively, in less-expensive models, a simple page count method is used to trigger the error LED to indicate that the ink pads should be checked and/or replaced.

In this particular case, the software tool that my client downloaded is used to reset the page counters and to modify other parameters. However, this tool should only be used once the problem(s) that caused the error state in the first place have been resolved. Resetting the page count without cleaning the waste ink pads will get the printer up and running again but the waste ink system will soon overflow and that's exactly what happened in this case.

Items Covered This Month

- DIY printer repairs can easily go wrong
- Faulty Sunna 1500TL solar inverter
- Road-kill resuscitation
- Fender guitar amplifier
- Faulty heatpump

Dave Thompson runs PC Anytime in Christchurch, NZ.
Website: www.pcanytime.co.nz
Email: dave@pcanytime.co.nz

Faulty Sunna 1500TL Solar Inverter

A little bit of luck coupled with determination to "give it a go" can often get an expensive bit of gear running again. It certainly paid off for L. W. of Rochedale South, Qld when he tackled a faulty solar inverter. Here's what happened . . .

After returning home from a 3-month caravanning holiday, I noticed that my Sunna 1500TL solar grid-tied inverter didn't appear to be working. The LCD was blank and there were no LEDs lit to indicate that it was providing power to the grid. In fact, it looked like it had gone into sleep mode which is what it does when the Sun goes down. The only trouble was that it was mid-afternoon in sunny Queensland.

I first tried to reset the unit by turning off the AC Solar Supply main switch, followed by the PV Array circuit breaker. After a short delay, I then turned the PV Array circuit breaker on again which should have started the inverter, lighting up all the LEDs and the LCD in the process. Unfortunately, nothing happened!

The next thing to do was to make sure that the voltage from the PV (photovoltaic) array was not only present but greater than 120V. A check with a multimeter soon confirmed that the open circuit voltage coming from the array was indeed well over 270V DC. So that meant that the problem was somewhere in the inverter.

This particular inverter came with a 10-year warranty but as I soon discovered, both the company that provided this warranty and the firm that installed the system just over two years ago were no longer in business. So there was nothing for it but to see if I could fix it myself.

Not feeling very confident, I placed the inverter on the workbench, removed the front covers and took a look inside to see if there were any obvious signs of distress. To my surprise, the whole unit looked to be very well made. The metal cabinet was very soundly constructed and the circuit boards all looked neat and tidy.

I began with a quick visual inspection and a "smell test" but there was nothing obvious, so I turned my attention to a fuse on the main circuit board. It tested OK so I turned to the internet to see what I could find out about this model inverter. There were a few tales of woe but not much more.

It was beginning to look like I would have to buy a new inverter but first I thought that I would take another look at it. After all, I had nothing to lose.

It was then that I noticed a small circuit board sitting vertically along the lefthand side of the case. This was plugged into the main circuit board and was easy to remove, so I extracted it and set it on the workbench for further investigation.

It appeared to be a power supply of some sort. There were a few labels on the pins that plugged into the main board and from these I was able to determine where the external supply voltage entered the smaller board. In addition, I was able to determine where the derived voltage rails left to go back to the main board.

At this stage, I decided to test the diodes, starting with D54. This was tested in-circuit and it appeared to be a partial short circuit. Removing it from the board proved that this was indeed the case.

Next, I checked D25 but this tested OK. D28, D29 & D30 all tested short-circuit however but removing them

In case you're wondering, the pads are usually inexpensive and relatively easy to replace. What's more, any printer repair agent worth his salt will give the printer a good clean and service while doing the pads, thereby extending the usable life of the printer.

In this case, I disassembled the printer on a workbench protected by a sheet of plastic cut from a bin liner. I then used lots of paper towels to sop up any surplus ink that was still sloshing around the inside. It was a real mess, although it cleaned up relatively easily with some methylated spirits and isopropyl alcohol. After that, it was just a matter of replacing the pads, cleaning the print heads with an ultrasonic cleaner, and resetting the counters.

Liquid gold

Printer manufacturers are quite insistent about the proper use of consumables because this is where the vast majority of their revenue comes from. Actual printer sales account for very little revenue because the profit margins on printers are almost nothing. However, the vendors recognise that, over the life of a printer, the end user may spend thousands of dollars on cartridges and so this is where the real money is.

Someone once claimed that printer ink had to be the most expensive liquid in the world and they might well be right, as least from the consumer's point of view. The reality is that printer ink cartridges cost mere cents to produce but in some cases sell for nearly $100, an amazingly high mark-up.

It's no wonder then that third-party cartridge suppliers and ink-filling companies flourished in the early 2000s as end-users sought to lessen the financial impact of feeding their inkjet printers. This in turn created a huge problem for printer manufacturers, as they saw revenues flowing instead into the coffers of those other companies.

As a result, they started getting clever with the inks they used and by manipulating the specific gravity and consistency, could tailor a specific ink for a given cartridge and printer. This meant that using cartridges with standard refill ink from third-party companies could result in the print head either blocking up due to the ink being too thick or the ink simply pouring through because it was too thin.

The refill companies soon took notice of this and began sourcing and using the different inks required to maintain their competitive edge. The printer manufacturers then went one step further and changed their warranty agreements to include the use of only original, factory-supplied cartridges.

Of course, printer repair outfits can easily recognise the symptoms of non-standard cartridges being used and customers using these cartridges have

one at a time proved D30 to be the real culprit.

I now turned my attention to the other semiconductors. The voltage regulators all checked out OK as did various other parts but when I came to Q27, the main switching device, it too appeared to be faulty. It turned out to be a Mosfet and it was short circuit between the drain and source.

It was then that I noticed what initially looked like a resistor mounted on its end but it was labelled as 'F1'. Closer inspection showed that it was a 2A fuse and it was open circuit.

All the diodes were 2A fast-recovery types, while the Mosfet was a 7A N-channel device. A quick search on the internet revealed that they could all be purchased in Sydney.

The fuse posed a bit of a problem because I was unable to source a direct replacement. In the end, I decided to try to remove the pig-tails from the blown fuse and resolder them to the smallest 2A fuse I had, even though this was twice the size of the original.

During this process, both the end-caps came away from the fuse body, leaving me with everything I needed to make a good new fuse except for some 2A fuse wire. This I was able to salvage from a 3AG 2A fuse I had on hand. After a bit of fiddling, I was able to solder this fuse wire in place and I then had a 2A fuse that looked just like the original.

Everything else seemed to check out OK, so I soldered the repaired fuse in place and waited for the other parts to arrive. They turned up a couple of days later and I wasted no time fitting them to the circuit board.

Once everything was in place, it was time to refit the circuit board to the inverter. I then reconnected the inverter to the solar panels and turned on the DC circuit breaker to see what happened. After a short delay, all the LEDs lit up and the LCD displayed the test cycle before eventually indicating that all was well. The yellow LED was lit, indicating that no utility was connected, and the green LED was flashing.

Finally, after reconnecting the AC wiring, I threw the main AC switch. The yellow LED immediately went out (indicating that the utility was present), while the green LED now remained on to indicate that the DC input was greater than the sleep power.

And that was it; the inverter has now been running happily for several months. I was lucky with this one but you never know what can be achieved unless you "have a go".

discovered that their printers were no longer covered under warranty, all because they wanted to save a few bucks on ink.

Other printer problems

Aside from any potential ink issues (easily avoided by using the correct consumables), printers are usually very reliable devices. Like any mechanical device though, they do need servicing and most printer repair companies will offer a general service for a reasonable fee.

Ink waste pads should be part of any regular check-up, while rollers need to be cleaned and various sensors checked for correct operation. These are all important elements in any printer. In addition, both inkjet and laser types are notorious for producing a fine dust that's quite abrasive and this can cause damage if it gets into the inner workings

Both printer ink and toner are surprisingly hard when dry and minute particles of wet ink or toner are created when the printer is operating (and also in inkjets when the heads are being cleaned). These tiny droplets or particles dry to form a large-grained dust and if this dust is allowed to build up on sensors and feed rollers, it can cause all manner of problems.

This means that cleaning up and removing this dust should be part of any printer maintenance or service schedule.

Another common problem is paper jams. This frustrating issue can have a number of causes, from the aforementioned dusty and/or dirty feed rollers to damp paper.

Be careful with paper jams

One of the worst things a printer owner can do when a page jams in the printer is to pull the paper out the wrong way. If the page hasn't yet appeared on the outside of the printer but is accessible from the inside, it's all too tempting to grab what can be seen of it and pull it back through. However, some of the rollers may be applying a lot of pressure to the paper (ie, to feed it through), which means that gears can be forced to rotate the wrong way (and thus damaged) or sensors can be knocked out of line.

If you get a paper jam in your printer and you can see the page from the output side (and can get hold of it) then by all means try to gently pull it through but avoid jerking the page or making any other sudden movements. Bear in mind that if it is still under tension from the feed rollers, the paper may tear and leave bits and pieces behind, so take it easy when pulling a jammed page through.

I've seen many printers in my workshop where the owner has pulled the page backwards through the rollers and damaged the printer's internal workings, so this should be avoided at all costs. If you are handy with a screwdriver, by all means strip the printer down to the level required to remove the page safely; Google and YouTube are handy tools for discovering how to properly tear down a printer but be warned it isn't all gravy.

Indeed, printers are just the type of device that can catch an unwary DIYer out. You only have to upset the gear meshing of a feed roller or the position of a sensor to render a printer completely unserviceable.

Of course, if your printer is one of those ultra-cheap models and you really have nothing to lose by diving in and having a go, then by all means crack on. Just be sure to take photos and keep a good record of what you take off and where it came from, so that you can later put it all back together again. If necessary, mark rollers and gears so that they go back into exactly the same position, as they are critical to the operation of the device.

Colour laser printers

With the advent of cheap colour laser printers, it's possible that inkjet-style printers will soon be a thing of the past. Lasers tend to be less "fussy" than inkjets but unless it's a really low-cost unit, you should use factory toner cartridges and other genuine replacement parts such as drums.

Plenty of companies also offer reconditioned drums and toner cartridges for laser printers and most will work with-

Road-kill resuscitation

Road-kill usually has a bad smell but K. D., of Chermside, Qld was able to breathe new life into a couple of no-so-smelly recent casualties. Here's what happened . . .

I was recently handed a bag that a friend had found on a busy main road. By the look of it, the bag had fallen from a vehicle moving at a fair speed or had been run over. When I took a look inside, I found a CABAC power point tester (TEL1TLV2) and a Fluke insulation meter (1577) complete with its test leads and accessories.

The power point tester appeared to have suffered the worst damage. The prongs on the 3-pin plug were bent at right angles, the case was split at the seams, the knob was bent at an angle and it rattled badly when shaken. I was about to toss it into the bin when I decided to at least have a look inside to see how it was made.

I began by removing the knob and the nut securing the switch. The welded seams of the plastic case were already mostly split and the unit cracked fully apart with some gentle levering. Once inside, I found that the rotary switch had been squashed almost flat, while the PCB was in three pieces. The neons and resistors all appeared intact.

On a whim (and ever the optimist), I decided to see if I could fix it. First, I de-soldered the remains of the switch and glued the PCB back together with Loctite 401 adhesive. A fibreglass pencil was then used to remove the solder mask at the breaks in the PCB tracks and these breaks were then bridged with wire links.

A rotary switch with the correct pin orientation was found on eBay for $5, while a replacement push-button switch came from my junk-box. These were fitted to the repaired PCB and a new 3-pin plug was fitted to the cord. The plastic case was then softened in boiling water and pushed back into shape.

Next, I scanned the original damaged label and created a new one with a graphics program. Once reassembled the unit worked as expected and so the case was glued together. It certainly doesn't look "as new" but it is both functional and safe.

By contrast, The Fluke insulation meter had suffered little visible damage. There were, however, a couple of tiny cracks in the case and some chipping on the edge of the clear plastic covering the display. In addition, the battery cover had been forcibly dislodged.

When switched on, the unit powered up but the display showed only a series of dashes. I downloaded the user and service manuals but the display I was seeing wasn't mentioned. I could, however, access the various power-on options, so I assumed that a lot of the circuitry was functional.

Removing the back cover immediately revealed one obvious problem. One of the heaviest components, surface-mount transformer T1, had broken away from the PCB and its

out problems but again warranties can be voided by using the wrong spares.

In short, check on your printer's warranty before buying consumables. As mentioned earlier, it often appears to be cheaper to buy a new printer than to replace toner cartridges and/or drums. However, keep in mind that many new printers ship with "starter" cartridges that only contain 10% or 15% of the actual capacity of a full cartridge. These are intended to get you up and running but will run out pretty quickly so you'll soon need a proper replacement.

Inkjet manufacturers also commonly do this, shipping their printers with low-volume cartridges that will print a couple of dozen pages (depending on actual coverage) but not much more. In both cases, you need to weigh up the benefits of buying a new printer over replacement consumables.

Finally, here's a tip to keep your inkjet printer printing nicely; at least once a week, try to print a small image using all possible colours to keep the print heads in good condition. If ink dries in the tiny matrix of holes in a print head, it's almost impossible to clear, even using the inbuilt head-cleaning system. Instead, an ultrasonic cleaner must generally be used to clear this type of blockage.

Printing an image that uses all the print heads will prevent them from drying out and causing this problem in the first place.

Faulty heat pump

A. F of Kingscliff, NSW was recently faced with a choice: fork out around $3000 for a new solar hot-water system or have a go at fixing his existing heat pump system. He chose the latter course . . .

When I moved into a new house recently, it had a heat pump system to provide hot water. As soon as I saw the heat pump unit, I took an instant dislike to it. It consisted of a large compressor box with copper pipes leading from it to a 400-litre hot-water cylinder located around the corner of the house.

The compressor unit itself had been installed at the end of the car port, exactly where I could see myself sitting in the shade in a comfy chair, with a nice cup of tea, reading a book. This big metal box stuck out into my entertaining area, darn it!

The unit had obviously been installed many years earlier and judging by the large copper pipes that came out of it and disappeared around the corner, it would not be easy to move. In the end, I decided that it could stay but I secretly hoped that it would soon break down. When it did, I could then replace it with a nice solar hot water system, which would be cheap to run.

My house is only about 200km south of the Sunshine Coast area, in an area of abundant sunshine, so why hadn't a solar system been installed? A few of my neighbours also had these heat pump systems and when I quizzed them, they told me the reason they had them installed was because they were so cheap to run.

Apparently, when the village was being built some years earlier, there had been several public meetings and the sales people had explained these units were very cheap to operate. And because of this sales pitch, many people had agreed to have them installed. However, I'm always sceptical about the claims of sales people, so I started doing some research of my own.

fine leads had also broken away from their mounting points on the former.

I began the repair by securing the transformer back in place with Dow Corning 314 conformal silicone. Next, with the aid of a microscope, some tinned copper wire and a very small soldering tip, I reconnected the stubs of the fine enamelled wires from the windings to the pads. I then reassembled the meter but it still displayed only dashes and wouldn't measure anything.

I disassembled the meter again and went over the entire PCB using a microscope, even removing the shielding and rotary switch contact assembly to check for cracks underneath. I couldn't find any more damage but when I put it back together again, it worked!

I can only assume that the rotary switch assembly had popped apart slightly on the road and that I'd completely re-seated it when I put it back together the second time.

So, with no real expenditure apart from my time and $5 for a switch, I'd resuscitated two useful pieces of test gear. Both items will come in handy.

One of my neighbours had an original installation manual, which I borrowed. The manual explained that this was a low-cost way of obtaining hot water because it heated the water by taking the "free heat energy" from the surrounding air. This explained why the salesman's pitch had been so successful. I guess that "Rated Power: 700 to 1400 W" on the information panel on the side of the heat pump means little to most people.

I recently had to repair one neighbour's solar hot water system which had a storage tank in the laundry. It had a water circulating pump about the size of a coffee mug and a small, simple control board. It was powered from a GPO in the laundry and it drew 14W when the pump was running. It runs for about two minutes every 20 minutes (or 2.4 hours a day), whereas my system runs every second night for about two hours. The difference is that my neighbour's solar system draws just 14W while it's running whereas mine uses 700-1400W.

I was glad when one day I found that I had no hot water. At last I could replace my heat pump system! However, when I looked at the price of a suitable solar hot water system, I found that I would have to pay over $3000. At that price, my joy quickly faded.

So I went outside and stared at the heat pump box. Of course, nothing was working because it was daytime and the supply to it was off-peak. This first came on at 1am, so I set my alarm clock to that time before going to bed that night.

At 1am, I staggered out into the car port with a torch, trying to convince my brain that a new day had begun. There was the loud sound of an electric motor and rushing air from the compressor box. So my unit had power to it and it wasn't dead.

The next morning, I found an ABS plastic box mounted on the side of the compressor box, along with a large isolation switch. There was no power to the circuit due to the off-peak state but to be safe, I turned off the isolation switch just to make sure. I then took the cover off the ABS box and discovered a circuit board with a PIC16F microcontroller chip and several large relays.

I now needed to have power applied to the system in order to make further checks. One possibility was that power wasn't being supplied to my system for long enough to heat the water properly. But applying power to a circuit which has been disconnected by the Energy Supply Company via the off-peak relay (Ripple Tone Control Relay) is a very unwise and illegal action.

In the end, I decided to ask my electricity provider how many hours of off-peak power were supplied each night. I phoned the company and it took me awhile to find someone who was knowledgeable on this subject. They asked me if I had received a letter from them stating that my ripple control relay had been upgraded. I said I didn't know, as I had only lived in the house for a few months.

After a brief discussion, they said that they would send an engineer out to check for the upgrade. And in less than 30 minutes an employee appeared at my door, said that my relay was OK and to prove it, he had switched on the supply.

That was great; I could now do some checking as the system had power. The fan was making a lot of noise again so I quickly dug out my multimeter and found that there was power to the circuit board and to the compressor terminals. However, the copper refrigerant pipes stayed at ambient temperature. Could there be a gas leak somewhere or was the compressor seized?

I turned off the power at the isolation switch and decided to check the large "Motor Run" 47µF 230V capacitor for the compressor motor. This was mounted next to the control board and if it was faulty, the compressor would fail to start.

Unfortunately, my capacitance meter was still buried in a cardboard removals box somewhere but I did have an old trick up my sleeve. Many years ago, I learnt that I could do a rough check on a capacitor using nothing more that the high ohms range on a multimeter and a stopwatch.

First, I completely discharged the 47µF start capacitor and disconnected both terminals. I then set my meter to the 200kΩ range, connected it to the capacitor and kept an eye on both the meter and my watch. The meter started at 0Ω and rapidly increased until it read "Out of Range". The time taken for this was just two seconds.

Next, I retrieved a spare 20µF 230V motor start capacitor from my junk box and repeated the test. This junk box 20µF capacitor took 40 seconds to charge – 20 times longer than the 47µF capacitor from the heat pump!

So the 40µF compressor capacitor from my heat pump wasn't much of a capacitor. I replaced it with the 20µF unit from my junk box and switched on the isolation switch. I then had to wait for the system timer to count up its obligatory 10 minutes (in case the Freon gas pressures have to equalise). At the end of this 10-minute period, the relays clicked and the system sprang into life.

I still couldn't tell if the compressor motor was working, due to the roaring noise from the fan motor. However, after a few minutes I detected that one of the copper refrigerant pipes was becoming warm to the touch, which was a good sign. It took a full 10 minutes before the pipe became hot, as the Freon gas liquefied on the high-pressure side of the system.

The system eventually ran for about six hours, during which time the water became increasingly hotter. It continued to work well with the 20µF motor start capacitor, so I left it in place until a replacement 47µF capacitor arrived.

Oh, the joy of being able to have hot showers again – not to mention saving around $3000! SC

By Nicholas Vinen

The Currawong Stereo 10W Valve Amplifier, Pt.3

In the last two instalments, we introduced the Currawong valve amplifier, described its circuit and gave the PCB assembly and wiring details. This final article describes the optional remote volume control, the acrylic cover and the setting-up procedure.

YOU DON'T HAVE to build the remote volume control board but we think most constructors will want to. It's just so convenient when it comes to setting the volume and is far easier than having to wander over to to wind the volume control up or down.

If you intend building the remote control into the Currawong, you should have already fitted the motorised pot to the main board. The 50 x 50mm remote board hangs from the front-right corner of the main PCB via a tapped spacer and is connected via a 4-pin header. There is also a connection from the remote control board to the pot motor.

If you aren't fitting the remote control option to your Currawong amplifier, skip down to the "Initial power up & testing" cross-heading below.

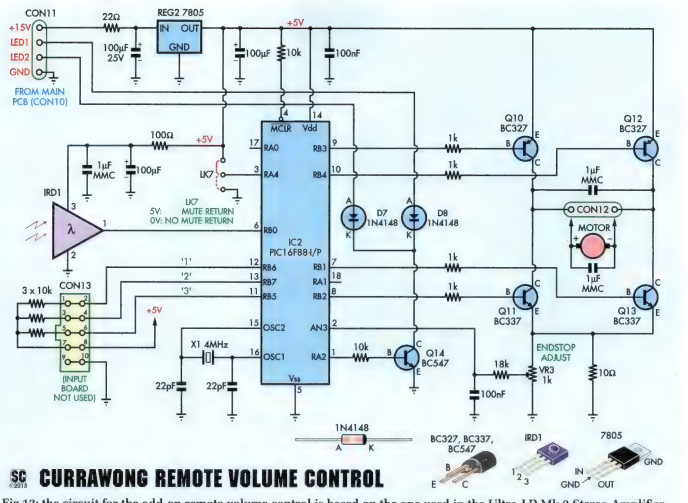
IR remote control circuit

The remote control circuit is shown in Fig.12. It's based on the low-noise remote-controlled preamplifier used in the Ultra-LD Mk.3 Stereo Amplifier described in the November 2011 issue.

Basically, we took the remote control parts used in that project and put them on a separate PCB, without the preamplifier circuitry (which is already present on the Currawong's main board).

It works as follows. The remote control is set to generate Philips RC5 protocol codes which are picked up by infrared receiver module IRD1. Its output goes to pin RB0/INT on PIC16F88 microcontroller IC2. IC2 decodes the remote commands and if it detects a relevant code (volume up/down/mute), it then uses its RB1-RB4 output pins to drive transistors Q10-Q13 which are arranged in an H-bridge configuration, to drive the pot motor in the appropriate direction.

A 1µF capacitor is connected across the motor terminals on the PCB to reduce hash from the motor brushes



CURRAWONG REMOTE VOLUME CONTROL

Fig.12: the circuit for the add-on remote volume control is based on the one used in the Ultra-LD Mk.3 Stereo Amplifier (November 2011). The infrared signal is received by infrared receiver IRD1 and passes to microcontroller IC2 which decodes it and uses Q10-Q13 to drive the pot motor in the required direction. Power comes from the main board.

while there is also a capacitor soldered directly across the motor terminals, at the other end of the figure-8 wire from CON12.

IC2 monitors the motor current across a 10Ω shunt resistor. The feedback voltage is adjusted using pot VR3 and goes through a low-pass RC filter (18kΩ/100nF) before being fed to analog input AN3 on IC2. IC2 can thus detect the increase in current when the pot hits one of its end-stops.

This feedback is used for the mute function. When mute is pressed, the motor is driven anti-clockwise until the pot hits its minimum end-stop. IC2 detects the increase in current and shuts the motor off once minimum volume has been reached. If mute is then pressed again and LK7 is in the high position, the motor is driven clockwise for the same time as it took to reach the end-stop, thus returning the pot to the original volume level.

For this to work, VR3 must be adjusted correctly. If it's set too high, the motor may stop prematurely while if set too low, the motor may not stop once minimum volume has been reached.

In the November 2011 design, IC2 flashed an acknowledge LED to indicate when a valid remote control command was received. We have used the same output (RA2) to drive NPN transistor Q14 which pulls the cathodes of small signal diodes D7 & D8 low in acknowledgement. These go to either end of red/green LED1 on the main board via pin header CON11. As a result, when a command is received, LED1 is shorted out and so it flashes off briefly. This avoids the need for an extra LED to be fitted for the remote control function.

The only change in the microcontroller software compared to the Ultra-LD Mk.3 remote preamp is to increase the time that pin RA2 is driven high upon receipt of a valid remote command. That's done in order to make the LED flashing more visible.

PIC microcontroller IC2 uses 4MHz crystal X1 for time-keeping. This is required as the remote control commands are sent at a particular frequency and the micro needs to be able to "lock on" to these commands to properly decode them.

Multiple input option

We've kept the original design's

Transformer Bolt Earthing – Warning!

Note that the mounting bolts for mains transformers T1 & T2 **must not** be separately earthed (ie, via earth leads) if the amplifier is mounted in a metal chassis. That's because running earth leads to them would result in a shorted turn on each transformer and this would immediately blow the fuse in the IEC socket.

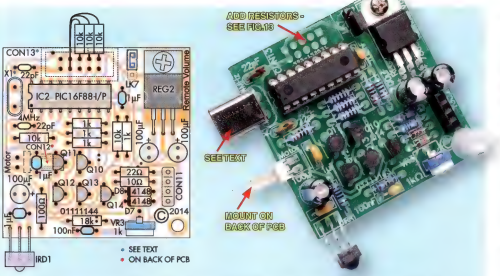


Fig.13: follow this parts layout diagram to build the remote volume control PCB. This sits just below the main board, so the available component height is limited. As a result, motor header CON12 and crystal X1 (if full height) must be fitted at right angles on the underside of the PCB (not on top as shown in the photo). In addition, the electrolytic capacitors should be pushed all the way down to the board before soldering or else bent over so that they will later clear the main board assembly.

10-pin header CON13, which was used to connect to two other PCBs for input switching. This enables the possibility of fitting multiple inputs to the Currawong and having remote-controlled switching. This would require the main Currawong board to be built into a larger case with enough room for the extra inputs and the relay board required.

In the standard Currawong design, (ie, no input switching), we just connect 10kΩ pull-up resistors from pins 7 & 8 (+5V) to pin pairs 1/2, 3/4 and 5/6 as shown so that the unit will function without the input switching board connected.

Power for the remote control unit is derived from the Currawong's unfiltered low-voltage DC rail of around 15V via pins 1 & 4 of CON11. This supply goes through a low-pass RC filter (22Ω/100µF) before being fed to a standard 5V regulator, REG2.

The 5V output from REG2 is used to power the micro and the motor but is further filtered using a 100Ω resistor and 100µF capacitor for infrared receiver IRD1 (plus an extra 1µF ceramic bypass capacitor) in order to prevent motor hash from interfering with infrared command reception.

Remote PCB assembly

The remote control PCB is coded 01111144 and the parts layout is shown in Fig.13. Start by fitting the two diodes, cathode stripe to the left, then follow with the resistors. You can check their striped bands against the resistor colour code table (Table 3) however it's also a good idea to measure them with a DMM as the colours can be hard to read clearly.

Note that while most of the resistors are laid flat in the traditional manner, the three 10kΩ resistors soldered to the pads for CON13 will need to be fitted vertically, with two leads sharing one of the holes. We used mini 0.25W resistors here, since they fit more easily.

Solder the IC socket in place next, with its notched end to the left, followed by REG2. Prepare the regulator by first bending its leads down through 90° about 6mm from the tab, then attach the tab to the PCB using an M3 x 6mm machine screw and nut. Make sure the screw is done up tightly before soldering and trimming the leads.

The ceramic capacitors can go in next; their polarity does not matter. You will be left with a 1µF type to be soldered across the motor terminals later.

Follow with the small signal transistors, taking care to avoid getting the three types mixed up. Crank their leads out to fit the PCB pads using small pliers. **If you have a low-profile 4MHz crystal, this can be fitted to the top of the board as shown in Fig.13. Otherwise, you will need to cover the metal can with a short length of 10mm diameter heatshrink tubing, shrink it down, bend the leads through 90° and fit it to the underside of the board so that it's laying horizontally under PIC micro IC2.** In this case, solder its leads on the top side of the board.

Note that in our photos, X1 is shown bent over to the left but this was found to interfere with the mains power switch when the board was in place, so we later moved it to the underside and bent it in the other direction as described above.

The right-angle polarised header for the motor is also mounted on the underside of the board, with its pins facing the righthand edge, for the same reason (again, shown differently in the photo). Solder its pins on the top side.

Table 4: Capacitor Codes

Value	µF Value	IEC Code	EIA Code
1µF	1µF	1u0	105
100nF	0.1µF	100n	104
22pF	NA	22p	22

Table 3: Resistor Colour Codes

❑	No.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	1	18kΩ	brown grey orange brown	brown grey black red brown
❑	5	10kΩ	brown black orange brown	brown black black red brown
❑	4	1kΩ	brown black red brown	brown black black brown brown
❑	1	100Ω	brown black brown brown	brown black black black brown
❑	1	22Ω	red red black brown	red red black gold brown
❑	1	10Ω	brown black black brown	brown black black gold brown

The 3-pin header for LK7 and 4-pin header socket CON11 are fitted as usual, to the top side of the board. Put the shorting block over LK7 in the position shown for mute return or fit it in the alternative position to disable mute return.

Trimpot VR1 is a vertical type, so that it can be accessed once the remote control board has been plugged into the main board. You will need to bend its rear pin out slightly to fit the mounting pads. The three electrolytic capacitors can then go in, with their longer (positive) leads orientated as shown.

The infrared receiver is fitted with its leads bent so that the bottom of the receiver is level with the PCB but it is spaced about 6.5mm away from the bottom of the board – see photo. You will need to bend its leads backwards close to the body of the receiver, then crank them up, then bend them back down again about 8mm behind the body of the receiver to fit through the holes on the PCB.

The final adjustment to make the infrared receiver "look" through its front panel hole will be done later, when the board is fitted.

You can now finish the remote PCB assembly by plugging microcontroller IC2 into its socket, with pin 1 at left.

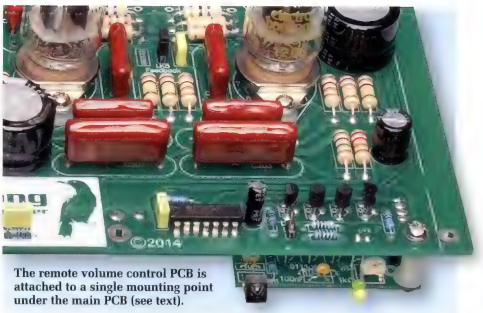
Installing the remote PCB

Solder a 4-pin male header to the underside of the main PCB, at bottom-right, to match up with the female header socket (CON11) on the remote board. While you're at it, feed the leads of the remaining 1μF ceramic capacitor through the holes in the two terminals on the back of the pot motor and solder them in place. Trim off any excess lead.

Now you will need to make up the lead for the pot motor. Start by cutting a length of light-duty figure-8 cable so that it will reach from the rear of the pot over to the right-angle pin header on the remote board. Be a little generous, keeping in mind the orientation of the plug and the fact that you will need some slack in order to plug it in.

Strip and separate the wires at both ends of this cable and crimp both wires at one end into two polarised header pins. We like to solder the wires after crimping (being careful not to get any solder outside of the crimp section) so that they can't pull out.

Next, push the pins into the polarised block using a small jeweller's screwdriver. They should click into place. If they won't go in, don't force them; you may need to pull them out and straighten the "springy" section before they will go in properly.



The remote volume control PCB is attached to a single mounting point under the main PCB (see text).

Now solder the other ends of the lead to the pot motor terminals (or to the capacitor leads which are already soldered to them). Unfortunately, there's no good way to figure out the polarity so you'll just have to pick one and then reverse the connection if it's wrong but we'll get to that later.

Next, insert an M3 x 6mm machine screw through the sole mounting hole on the remote control board, head on the underside, with a shakeproof washer under the screw head. Place a Nylon washer on top and then screw it into an M3 x 9mm tapped spacer. Do it up nice and tight.

Plug the remote board into the 4-pin header on the main board, then use another M3 machine screw and a flat washer to hold it in place via the provided mounting hole on the main board. Finally, plug the polarised header from the motorised pot into CON11 on the bottom of the remote board and you are ready to test it.

Note that the pot motor lead should not be able to reach the mains switch which, in any case, should be completely covered in heatshrink tubing.

The next step is to drill a 4mm-diameter hole in the front panel for the IR receiver. **This 4mm hole should be positioned exactly 27mm to the left of the power LED (LED1).** Having done that, leave the front panel off for the moment, so that you can set VR1 correctly and if necessary, swap the motor polarity.

Initial power up & testing

When we left off last month, we had built the PCB and plinth, wired up the

WARNING! HIGH VOLTAGES

High AC and DC voltages are present in this amplifier. In particular, mains voltages (230VAC) are present on the IEC socket and the primary side of the mains transformers (including the wiring to the power switch). In addition, the transformer secondaries together provide a 114VAC output and the power supply produces an HT voltage in excess of 300V DC which is present on various parts of the amplifier circuit (including the output transformers).

Do not touch any part of the amplifier or power supply circuitry when power is applied otherwise you could get a severe or even fatal electric shock.

The blue LEDs in the circuit indicate when high voltages are present. If they are lit, the power supply and various parts on amplifier board are potentially dangerous. **The completed amplifier must be fitted with Perspex covers as described in Pt.3 this month, to ensure safety.**

Parts List: Currawong Remote Control

1 double-sided PCB, code 01111144, 50 x 50mm
1 4-pin header, 2.54mm pitch (CON10)
1 4-pin female header, 2.54mm pitch (CON11)
1 1kΩ mini vertical trimpot (VR1)
1 4MHz crystal, HC-49 (low-profile if possible*) (X1)
1 3-pin header, 2.54mm pitch, with shorting block (LK7)
1 18-pin DIL IC socket
1 2-pin right-angle polarised header
1 2-pin polarised header plug with crimp pins
1 200mm length light-duty figure-8 cable
1 9mm tapped Nylon spacer
3 M3 x 6mm machine screws
1 M3 nut
1 3mm ID shakeproof washer
1 3mm ID flat washer
1 3mm ID Nylon flat washer
1 universal remote control (eg, Altronics A1012, Jaycar AR1719)

Semiconductors
1 PIC16F88-I/P programmed with 0111114A.HEX (IC2)
1 infrared receiver (IRD1)
1 7805 5V linear regulator (REG2)
2 BC327 PNP transistors (Q10,Q12)
2 BC337 NPN transistors (Q11,Q13)
1 BC547 NPN transistor (Q14)
2 1N4148 signal diodes (D7,D8)

Capacitors
3 100µF 16V electrolytic
2 1µF monolithic multi-layer ceramic
3 100nF monolithic multi-layer ceramic
2 22pF disc ceramic

Resistors (all 0.25W, 1%)

1 18kΩ	1 100Ω
5 10kΩ	1 22Ω
4 1kΩ	1 10Ω

* If using a full-height can crystal, add 1 x 20mm length of 10mm-diameter heatshrink tubing

power supply and mounted the PCB in place. Now it's time to power it up *without* the valves in place and check that the power supply is working.

Start by popping the fuseholder out of the mains input socket using a flat-bladed screwdriver, then fit the fuse (plus a spare) and re-install it. Leave LK4 & LK5 off the board for now. **From this point on until the top cover is fitted, be careful to avoid putting either of your hands near any of the components on the top of the board – touch the assembly using insulated probes only.**

Now set your DMM to DC volts (with a range that goes up to at least 300V), plug in the mains cord, switch on and observe the LEDs. The four blue LEDs adjacent to output transformers T3 & T4 (LEDs3-6) should immediately light. Blue LED2, next to the headphone socket should remain off while LED1 (power) should be red.

If your amplifier doesn't display this behaviour, switch off immediately and wait for the HT voltage to drop to a safe level before troubleshooting. This can be monitored by connecting the negative probe of your DMM to one of the valve socket mounting screws and the positive to the cathode (striped end) of D1. Wait for it to drop below 40V before touching the board and to 10V before doing any soldering or other work on the board.

Assuming blue LEDs3-6 are working properly, these indicate the state of the HT rail. They will be glow brightly when dangerous voltages are present and dim significantly once the HT capacitors have discharged to a safe level. Note that they will continue to produce a small amount of light for a long time after switch-off but will be quite dim by the time the HT rail drops below 10V or so.

If these LEDs do not light up, one or more could be installed with the wrong polarity or might be faulty. Once the HT has discharged, you can connect a current-limited voltage source across each LED to check them. Some (but not all) multimeters can light blue LEDs when set on diode test mode.

If LEDs3-6 are working but LED1 does not come on, this points to a possible fault in the low-voltage AC wiring, the regulator section or a problem with IC1 or Q5-Q8 and associated components. Check these areas, starting by measuring the voltage between pins 4 & 5 (the two topmost pins) of one of the 9-pin valve sockets, which should be stable at just above 12V and proceed from there.

On the other hand, if LED2 is on, that suggests a fault in Q9 or its base resistor or a short circuit in that section of the board.

Assuming that you get the correct LEDs lighting, LED1 should turn green about 20 seconds after switch-on. During this time, you can check that the various voltage rails are correct.

First, measure the DC voltage between pins 4 & 5 of the 9-pin valve sockets as mentioned above and check that you get close to 12.3V. You can also confirm that there isn't too much ripple on the regulated supply by measuring the AC voltage between these pins; it should be below 100mV.

Now check the unfiltered HT supply voltage, between the cathode of D1 and one of the valve socket mounting screws. You should get a reading close to 320V.

The filtered HT voltage can be measured between pin 3 of any 8-pin valve socket and one of the earthed mounting screws. Pin 3 is the pin closest to you, on the right – see Fig.6 in Pt.2 last month. This should give a low reading (a few volts) initially while LED1 is red and then it should shoot up to 318V or so (ie, a couple of volts below the unfiltered HT rail) as soon as LED1 turns green.

The other filtered HT rails can also be checked, at pins 1 & 6 of each 9-pin valve socket (lower-right and upper-left respectively). With the valves not yet fitted, these should all be pretty close to the main filtered HT rail at around 318V although they will rise more slowly after LED1 turns green.

Testing the remote board

If you have fitted the remote control board, this is a good time to test it now that you have determined that the power supply is working properly. First, set your remote control to one of the supported codes. For the Altronics A1012, this is either 023 or 089. For the Jaycar AR1719, use 97948 (Philips 02 CJ 412 TV).

Now aim the remote control at the receiver and hold down the volume up or volume down button. You should see the acknowledge LED (LED1) flash and the pot shaft rotate.

If nothing happens and you have definitely programmed the remote for the correct code then that suggests either a fault on the remote control board or an improperly programmed PIC micro. Check that the board's 4-pin

header (CON11) is plugged in correctly to the main board and that there is around 15V between pins 1 & 4.

If the pot rotates in the wrong direction, you will need to switch off and reverse the motor connections (once the HT rail has discharged sufficiently). This can be done by using a fine flat-bladed screwdriver to press in the retention tabs on the polarised header pins, then sliding the pins out of the housing (while holding the tabs down) and refitting them so that they are swapped around.

Once you have the pot motor rotating correctly, press the mute button and check that the pot rotates to the fully anti-clockwise position and stops. If it doesn't stop, turn VR1 clockwise until it does. If it only rotates part of the way, turn VR1 anticlockwise until it mutes properly.

Ideally, VR1 should be set about mid-way between the too-low and too-high positions, to avoid later malfunctions if the pot shaft's mechanical resistance increases slightly.

Note that you may need to manually rotate VR1 clockwise to about half-way (or use the volume up button) before the mute function can be tested. Once it has been set up, you can refit the front panel and if necessary, bend the leads of IRD1 and LEDs1&2 so that they line up with their respective holes.

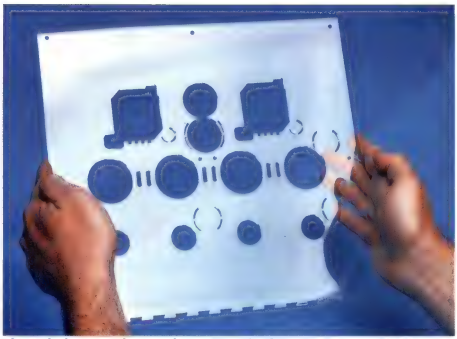
Fitting the valves

Assuming that the voltages check out, switch off the power and wait for the HT capacitors to discharge, then plug in all the valves. The sockets will probably be very stiff the first time they are fitted; a small amount of contact cleaner on the pins can help ease them in.

Don't push them too hard; you will need to wiggle them in and it's better to push down on the octal valves by holding the base rather than the envelope. The 12AX7s have no base but they should require less insertion force anyway.

The glass envelopes are pretty strong but they can be broken with enough force and there's also the possibility of the glue holding the envelope to the base giving way. So slowly wiggle the valves in. After the first couple of insertions, the sockets will loosen up and fitting/removing the valves will be a lot easier.

This may seem obvious but we should point out that V5-V8 will get very hot during operation and you should not touch them! Even brief contact can result in a painful burn. Consider that with the glass envelopes and about 25W dissipation, they are similar to an incandescent light bulb – ie, they get very hot!



This is the laser-cut clear acrylic top cover for the main PCB assembly (the white colour is a reflection). Not shown are the front cover and the four pieces that are attached as shield plates to guard the output transformer connections. Acknowledgements: we'd like to thank Ada Lim and the people at Sydney hackerspace "Robots & Dinosaurs" for their help with the laser cutter.

Now, while we have provided a minimal output load on the PCB (~470Ω per channel), it's still a good idea to hook up a "proper" dummy load until you're ready to connect some speakers, to prevent flash-over due to excessive voltage when the amplifier is lightly loaded. A couple of 10Ω 5W resistors connected across the speaker terminals will do, although any value in the range of 3.9-100Ω is acceptable.

Turn the volume control right down initially. If you have an oscilloscope and signal generator, you can feed sinewave signals into the inputs, power the unit up, advance the volume control and check the shape of the output waveforms on each channel. Otherwise, all you can really do is hook up a signal source (eg, a CD player) and some speakers and listen to it.

Note that there won't be much output (if any) until several seconds after HT has been applied (ie, LED1 has turned green), as it takes time for the various bias voltages in the circuit to stabilise. And it takes several more seconds until the amplifier can deliver a significant portion of its rated power. The warm-up is complete and the full ~10W/channel is available around 10 minutes after switch-on.

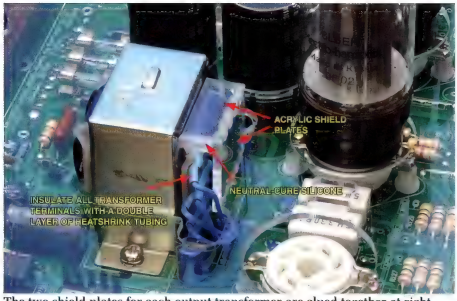
Before that, you'll probably run into clipping at 8-9W per channel. It simply takes that long for the valves to reach operating temperature.

Assuming it appears to be working normally, switch off, turn the volume control back down and fit shorting blocks to LK4 and LK5 to enable global feedback. This dramatically lowers distortion, from around 0.5-1% down to 0.05-0.1% (ie, by at least an order of magnitude) so we definitely recommend operating the amplifier with these links in.

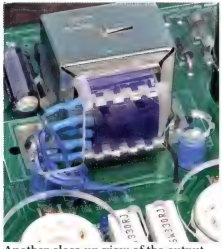
Now switch the amplifier back on, slowly turn the volume back up and check that it's still working properly. If you get a high-pitched squeal, you may have wired the output transformers improperly, turning the negative feedback into positive feedback and causing oscillation. You'll have to switch off and check the transformer wiring and feedback components (resistors/capacitors).

Making the top cover

The top cover is vital since contact with some of the components during operation could be lethal. We've designed a clear acrylic top cover to suit the plinth as described last month, so you can still see all the circuitry while keeping it safe. It also helps to keep dust and dirt off the board (although



The two shield plates for each output transformer are glued together at right angles and then glued at right angles to the main cover. Some neutral-cure silicone is also used to provide further protection and to help hold the acrylic shield plates in place.



Another close-up view of the output transformer shield. Don't leave this shield out – the transformer terminals operate at 308V DC so it's an important safety feature.

not entirely, since there are cooling slots cut into it).

Technically, acrylic plastic is polymethyl methacrylate and is sold (with some variations in the formulation) under several brand names, including Plexiglas, Perspex and Lucite.

The cover panel likely won't be included in any kits but you can purchase it direct from SILICON CHIP (eg, via our online shop). Alternatively, if you have access to a laser cutter with a bed of at least 300 x 300mm, you could cut it yourself. The cutting file is available on our website in various formats including DXF, SVG and PDF (as a free download for subscribers).

We used a laser cutter with a 50W CO_2 laser and found that we got good results cutting the 3mm acrylic using two passes at 50% power.

Once you have your cover, check which way around it goes (the cutouts are not symmetrical), then slip it over the top of the assembly to make sure that it fits in place and that the plinth mounting holes are not too far out of their expected positions. Leave the protective film on for the time being. **If you're using valves with large envelopes (eg, KT66s) then you may have to remove them in order to fit the cover.** 6L6s can be left in place. Push it down until it sits on top of the low-profile 39µF capacitors.

If it won't go all the way down, chances are you haven't positioned transformers T3 & T4 in the middle of their mounting locations. It's possible to carefully loosen their mounting screws, just enough to move the transformers, then tighten them again without having to remove the board.

Now remove the cover and peel the protective film off the five pieces to be glued. These all have crenellated edges (like a castle rampart, with a series of square protrusions). **While super glue (cyanoacrylate) is suitable for gluing acrylic, we strongly recommend that you use a proper, solvent-based adhesive as this will give a much stronger bond.**

We used SciGrip Weld-On 16, fast-setting "clear, medium-bodied solvent cement". This states on the label that it's suited for Butyrate, Polycarbonate, Styrene and Acrylics. You are unlikely to find this type of adhesive in a hardware store but should be able to get it from a plastics supplier. Ours came from Plastix (Sydney (02) 9567 4261; Sydney Northern Beaches (02) 9939 0555).

This forms a strong bond quickly so you only have about 30 seconds to mate the pieces and ensure that they are square before it's too stiff to manipulate. Full strength is achieved after about 24 hours. The bond is clear but you don't want to get excess adhesive on the material as it will affect the surface finish and you definitely don't want to drip it on the cover. It tends to get a bit "stringy" (sort of like melted mozzarella) after coming in contact with the acrylic.

In fact, to give yourself the best chance of getting a clean-looking bond, we'd recommend squeezing some of the adhesive out onto a smooth piece of timber or metal (not plastic!) and using a small paintbrush (hair, not Nylon) to apply it to the acrylic. This makes it easier to control how much you are applying compared to using the tube directly. You'll also need a clean rag on hand.

Start by gluing the two pairs of transformer shield plates together. Before applying any adhesive, figure out which surfaces will be in contact (they are on two faces). That done, apply a thin layer of adhesive to all those surfaces, then press the two pieces together. Make sure that they are at a 90° angle and that the tabs are fully inserted into the slots. Wipe off any excess adhesive and be careful not to get it on areas of the acrylic away from the join.

You can then lay the part on its side to cure. Do the same for the other identical piece. Note that while there are two different orientations in which these pieces can be glued together, it doesn't matter which way you do it as they are symmetrical.

Once you've done those, you can move onto gluing the front and top sections together. This is a much larger join but the technique is basically the same. **However, the orientation does matter in this case – be sure to glue the front section on such that when the cover is in place, it hangs down rather than sticks up.** Acrylic adhesive is very strong so if you get it wrong, you probably won't be to get them apart

This view shows the amplifier with the acrylic cover in place. It provides an attractive finish while protecting against dangerous voltages. Note that the output valves get hot so be sure to place the amplifier away from young children and where there is plenty of ventilation.

Before Switching On

- Check that the IEC socket's Earth pin is connected to all exposed metalwork.
- Check the isolation between the Active & Earth pins and Neutral & Earth pins of the IEC socket.
- Check the output transformer and mains switch insulation. The output transformer terminals must be fully insulated with a double layer of heatshrink.
- Don't touch any parts if the unit is being tested without the cover.
- Be sure to fit the cover when testing is complete.

again without breaking something.

Again, it's important to make sure that the sections are at right angles and pushed fully together to get a neat result. You will need to peel away the protective film from the top cover near the front but it's a good idea to leave it in place on the rest of the panel to protect it during gluing. The best way to do this is to peel back the film around the area to be joined and then use a pair of scissors to cut a strip of it away, so the rest can be laid back down on the surface.

Once you've joined those parts, leave it for a few minutes and it should then be strong enough to allow you to glue the two transformer cover pieces prepared earlier into the crenellated sections at the front of the transformer cut-outs. Glue the pieces in so that the horizontal pieces at the top project out over the cut-out areas in the top cover below (ie, not pointing towards the front of the panel).

Fitting the top cover

While full strength won't be achieved for 24 hours, the joins should be strong enough after about 10 minutes to allow you to (carefully) fit the cover to the amplifier. Again, if using KT66s or other valves with envelopes larger than the 6L6s, remove them first.

Lower the cover until it's resting on top of the five low-profile capacitors. Take care to avoid touching the underside as this may leave visible fingerprints. If you do get fingerprints, polish them off with a soft cloth.

You may need to push down on it gently but firmly to get it to go all the way down. If it won't go, re-check the positioning of T3 and T4 and move them slightly if necessary.

You can then mark out the seven mounting hole positions around the perimeter of the cover and drill 2mm pilot holes a few millimetres deep in each location. You can remove the cover to do this if you want to (which makes it easier to remove the resulting wood particles), however it isn't strictly necessary.

Next, peel the protective film off seven of the small doughnut-shaped laser-cut pieces. Once you've cleared the area around each hole, slip these "doughnut" spacers under the cover and push them into place (eg, using a screwdriver). You can then feed a 4G x 12mm self-tapping screw in from the top and do it up until the top panel is resting on the spacer. You may want to do up all seven screws loosely and then slightly adjust the top cover position before making them all tight to hold it in place.

All that's left now is to squeeze a small bead of neutral-cure silicone sealant into the gap at the upper-left corner of each output transformer. This helps hold the acrylic covers in place and also prevents small fingers or other objects from being pushed into this gap (see photo). The easiest way to do this is to cut a thin strip of plastic from a take-away container lid or similar, place a bead of silicone on the end and use it like a trowel to push it into the gap and wipe off any excess.

Once it has all dried you can plug the valves back into their sockets and the amplifier is ready to go! **Note that the output valves get hot in operation so be sure to place the amplifier where there is plenty of ventilation.** SC

ALTRONICS

Build It Yourself Electronics Centre

Issue: January 2015

Back To Work Deals

Smartphone & Tablet Repair Tool Set T 2164

$29.50 NEW!

A handy tool kit designed to have everything you need to disassemble and repair most smartphones and tablets. Includes plastic pick, spudgers, tweezers, suction cup and a full set of security bit drivers (including pentalobe).

Waterproof Head Torch X 0202

$15 SAVE 24%

Weatherproof design with 4 high brightness white LEDs and headband. Two brightness levels & flash mode. Requires 2xAAA batteries.

$19.95 NEW!

High Current USB Charger M 8625

Huge 4.8A current output. Ideal for charging two phones or tablets at once.

D 2325

$56 SAVE 19%

NEW Qi 'Cable Free' Charging Pad

A slimline 3 coil charging pad for phones equipped with Qi charging (or those fitted with a Qi case). Just put your phone on the pad and it charges instantly!

Tuff Nut EQUIPMENT CASE

Extra Tough Equipment Carry Cases!

IP67 rated for the ultimate dust and water protection for your precious equipment. Ideal for storing test equipment, cameras, computers and sensors. Foam inner can be customised to suit your equipment. Foam lined lid for secure fit. Latches can be padlocked. T 5052-65 include shoulder strap.

Size	Part	Normally	Now
365x266x165mm	T 5050	$98.50	$73
465x365x185mm	T 5052	$179	$134
515x435x199mm	T 5054	$269	$199
650x430x250mm	T 5065	$485	$360

You Save 25%

*Dimensions external

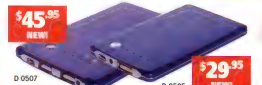
10 Way AV Power Protection Board P 8268

$39 SAVE 20%

Cheap insurance for your valuable home theatre - with surge protection up to 52,000A. Dual USB sockets for charging your devices, plus phone & aerial protection.

With 2 USB charging outputs!

$45.95 NEW!



D 0507 D 0505

$29.95 NEW!

NEW Super Slim Battery Banks

Recharge your phone on the go! Amazing slimline profile, fits easily in your pocket. **D 0507:** Dual USB 5V 1A and 5V 2A outputs, 5600mAH. **D 0505:** Single USB 5V 1A output, 3500mAH.

New Virginia, QLD Store

NOW OPEN!

1870 Sandgate Rd, Virginia QLD.

Check our website for more details.

$285 SAVE $30

T 2000

Thermaltronics® are widely used in the medical industry for servicing sensitive equipment.

Thermaltronics® 80W Digital Soldering Station

Revolutionary new soldering station design uses special alloy tips for incredibly fast start up time (under 10s) & heat regulation. Cartridge tip design eliminates the need for ceramic elements. Dual outputs for use with extra handle. Includes 1.5mm chisel tip.

T 2630 Iron & Cartridge

$99 SAVE $20

125W Iroda Portable Gas Cartridge Tool

- Powered by refillable butane cartridge • Totally wireless operation - No need to run extension leads • Super tough design will last for years
- Easy to light, one-click piezo ignition
- High reliability long life tips • Blow torch & soldering iron in one • 2 year warranty

$119 SAVE $40

This kit version of the T 2630 includes hot air tip, heat deflector, additional gas cartridge, solder, sponge and hard carry case (T 2631). Powers on for up to 4 hours from a full tank of gas!

T 2631 Full Kit

Top quality!

T 2487

$54.95 NEW!

Variable Temperature Soldering Iron

This great adjustable soldering iron is easy to use and flexible enough to tackle small or big jobs. Adjustable between 200° and 500°.

Tip has inbuilt LED lamp

T 2699

$22.50 SAVE 19%

Amazing USB Powered Soldering Iron!

This lightweight unit is perfect for occasional soldering jobs with surprisingly good performance. Includes adaptor for running from a 9V battery and sponge. Fitted with ultrafine tip capable of temperatures up to 480°C! **Check out the YouTube video online.**

Our Build It Yourself Electronics Centres...

Virginia QLD: 1870 Sandgate Rd • **Springvale VIC:** 891 Princes Hwy • **Auburn NSW:** 15 Short St • **Perth WA:** 174 Roe St • **Balcatta WA:** 7/58 Erindale Rd • **Cannington WA:** 6/1326 Albany Hwy

Phone Order Now On...

1300 797 007

or shop online 24/7 at www.altronics.com.au

The Best Workbench Deals

Ultra Bright LED Inspect-A-Gadget.

Ultra-bright long life LED for fantastic clarity (plus no need to change a globe - EVER!). Let "gadget" be your eyes. Identify those impossible to read miniature components without straining your eyes. Great for collectors, model makers, jewellers etc.

$99 TOP VALUE! X 4201 5 Dioptre

$95 TOP VALUE! X 4200 3 Dioptre

T 2555 $29.95 NEW!

Magnifier Head Goggles
Offers 1.5, 2.6 and 5.8x magnification with in-build LED lamp (requires 2 x AAA batteries).

$22 SAVE 15% T 2745A

Super Comfy Precision Snippers
Ideal for trimming component legs.

$16 SAVE 19% T 2748

5" Carbon Steel Side Cutters
Tough carbon steel blades, stay sharp longer. Ideal for cutting solid core wires.

$9.95 TOP VALUE! T 2191

Stubby Ratchet Driver
A must have for the glovebox or kitchen drawer! This little driver houses 7 bits, ready when you need it. *Colour may vary.

$149 NEW! $ 8746

The mechanics best friend!

Wi-Fi Handheld Inspection Camera
Ultimate accessory for plumbers, electricians, mechanics and more! 1m flexi gooseneck with 9mm camera. Transmits video back to your iOS or Android device. In-app recording, photo snapshot and 3x zoom. Rated to IP67. Requires 4xAA batteries.

T 4015 $12.95 NEW!

Never lose a screw again when working!
This magnetic workmat keeps those tiny screws and washers in place when performing servicing or repairs. 25x20cm. Includes marker.

H 0232 $9.95 NEW!

Handy Parts Storage Trays
Polycarbonate parts trays with 5 dividers. The same trays we use in our stores! Parts for illustration purposes.

$30 SAVE 24% T 2152

19pc Field Technicians Tool Kit
Includes an array of handy tools: • Needle nose pliers • Bent needle nose pliers • Serrated pliers • Side cutters • Bull nose pliers • Flat pliers • Fine tip tweezers • 3 x philips #00, #0, #1 • 3 x flat blade 2.0, 2.5, 3.0 • 6 x star/torx T6, 7, 8, 9, 10, 15

Reduce Heatshrink Instantly!
Iroda® Pocket sized thermo-gun. Great for reducing heatshrink, removing adhesives & paint. With a flick of the trigger it instantly powers up to 650°C!

T 2480

With a refillable cartridge $29 SAVE 17%

T 4704 $65 NEW!

Amazingly stable and portable.

Portable Cable Reel Stand
Lightweight and easy to move around. Great for installers. Suits reels up to 400D x 430Wmm. Max reel weight 25kg.

T 4632A $79.95 SAVE $20

Top deal on a popular model!

Make running cables easy!
Polyester coated cable snake for running cables through conduits, wall cavities and false ceilings. 30m length.

T 4636 $29 SAVE 10%

Glow In The Dark Cable Snake
Hard wearing 4m plastic coil makes running cable through a roof or wall cavity a breeze.

$24.95 NEW! T 2173

30pc Precision Driver Kit
An aluminium driver with rotating ferrule top for easy servicing of precision high tech devices and comms equipment. Includes 70mm extension bar and 28 x 4mm hex bits. **See web for full list of bits.**

T 2964 $11.95 NEW!

Self Fusing Silicon Tape
A cross between insulating and self-amalgamating tape. It waterproofs & insulates in one wrapping. 25mm wide. 3m length.

Coaxial Ratchet "Easy Crimper"
A pro quality crimper with all steel construction. Ratcheting action makes crimping BNC, TNC and PL259 plugs easier on the hands. Suits a wide range of cable including RG6, RG58 and RG59.

Great value! $29 SAVE 27% T 1554

Combo Wire Stripper & Kwik Crimper
Combines a ratchet wire stripper, cutting blade & kwik crimper in a single tool. Saves space in the toolbox! Suits 10-24 AWG cable.

T 1528 $22 SAVE 26%

$29 SAVE 26% T 5000

Super Sturdy Tool Case
Aluminium panels with reinforced corners & seams. Locking latches.Inner foam can be customised. 330x230x90 mm.

$22 SAVE 25% T 5032

$10 SAVE 33% T 5030

Handy Tool Carry Cases
Impact resistant plastic tool cases with removeable centre section.
T 5030: 315x175x130mm.
T 5032: 410x210x185mm.

Test & Measure Save up to 25%

Wide voltage range and high current output!

$379 NEW!
M 8310 0-30V 20A

$599 NEW!
M 8312 0-30V 30A

Compact & Efficient Lab Power Supplies

Bench top power supply for use in servicing, repair and design of electronics. The low noise switchmode design offers excellent regulation for low current requirements. Offers the flexibility of both wide adjustable voltage & current range. Size: 336W x 87H x 214Dmm.

Must have for electronic servicing.

Q 2115
$229 SAVE $30

Peak® USB Semiconductor Analyser

Much like our popular Q 2100 Peak analyser with added features including PC/USB interface which allows detailed curve tracing analysis of components, plus measure a range of part values like gain and leakage. 2 year warranty. **Designed & made in the UK.**

New higher resolution LCR functions

Q 2112
$199 SAVE $20

Peak® LCR & Impedance Analyser

Identifies inductors, capacitors and resistors. Can also display the components parameters as a complex impedance, complex admittance or magnitude and phase of impedance. 2 year warranty. **Designed & made in the UK.**

Network Cable Tracer & UTP Cable Tester

Combines the functionality of a cable tracer and tester in the one unit. Injects an audible signal down the line to make it easy to find the lead you're looking for with the included probe unit. Requires 3 x AA and 1 x 9V batteries.

Navigate those cabling rat nests!

Q 1341
$99 NEW!

Battery Health Analyser

Detects and analyses voltage, cold cranking amperes, resistance and cell condition in 12V lead acid cells. Easy connection and on screen menu driven operation. Ideal for vehicle servicing or checking 12V SLA cells in battery back-up systems.

Q 2120
$169 NEW!

Quick and accurate indication of battery health.

AC Clamp & Digital Multimeter Combo

Slimline design combines both digital multimeter and an 400A AC clampmeter into one unit. Superb ease of use makes it perfect for working on live equipment. An essential for high voltage technicians, electrical trades etc.

Features:
- Capacitance
- Temperature
- Resistance
- 400A AC
- DC V to 600V

Q 0964
$50 SAVE 15%

Measure wind speed & temperature easily.

A compact thermometer & anemometer with max speed of 108km/h. Great for ventilation monitoring, experiments etc. Includes battery. Very easy to use!

Q 1250
$69.95 NEW!

Autoranging Multimeter

The perfect enthusiast multimeter for under $30! Features temperature range (probe included) and data hold function. 10A current range.

$20 SAVE 25%
Q 1130A

Bargain Non Contact Thermometer

Affordable and high spec IR thermometer for measuring temperatures without contact. -50°C to 500°C. 12:1 resolution. Great for technicians, mechanics, even food safety.

$49.95 NEW!
Q 1283

Moisture Meter

Measures moisture levels in wood and building materials such as concrete, plaster, mortar etc. Ideal for monitoring damp or moisture ingress. Requires 9V battery.

$34.95 NEW!
Q 1255

Super special!

$399 SAVE $160

Zeroplus® Powerful PC-Based Logic Analyser

Q 2204

The Zeroplus LAP-C series are 16-Channel, PC-based Logic Analysers with powerful protocol analyzer capabilities. Connects via USB to provide a complete suite of PC analysis tools to your workbench. Includes protocol decoder plugins for I2C, SPI, UART & 7-Segment (plus many more!). An additional 30 free protocol decoder plug ins can also be downloaded. Inbuilt waveform compression technology increases the effective memory capacity far beyond the physical 2MBit.

An Altronics Best Seller!

Q 1098
$139 SAVE $40

Protek® True RMS Datalogger

The full house multimeter, packed with features and value! Excellent for research, design & service. • Dual display with bargraph • Logic test • Decibel capacitance, inductance & temperature • Pulse signal injection • MIN, MAX, AVG & relative modes • Continuity & diode test • Fused 20A input • Data hold & run.

Q 1088
$99 SAVE $20

Water & Dustproof True RMS Multimeter

Top of the range! Ideal for marine & mining technicians.
- True RMS measurement
- 40MHz freq. counter with bar graph • Data hold • Max/min recording • Capacitance to 40mF. • Temperature with thermocouple • 10A current.

Tough steel case!

Q 2022
$37 SAVE 25%

'Roadies' Cable Tester

Tests 13 types of leads for continuity. A real time saver! **Tests:** 6.35mm, DIN (3/5/7/8 pin), RCA, XLR (3/5 pin), Speakon (4P/8P), RJ45, USB & banana.

T 2260
$35 SAVE 23%

Digital Pocket Scales

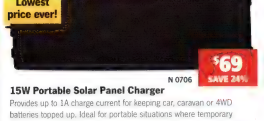
Great for measuring and counting lightweight items. Measures in grams, ounces, troy ounces & pennyweight. 0.1g resolution. 500g max. Includes cover.

Precision Audio Impedance Meter

Measures transformer & speaker impedance accurately and easily. Applies a test tone to any speaker or transformer circuit. Suitable for both 4-8 ohm & 100V line systems. Requires 6 x AA batteries.

Q 2005
$199 SAVE $50

Big Savings On **Power Gear**



Lowest price ever!

N 0706

$69 SAVE 24%

15W Portable Solar Panel Charger

Provides up to 1A charge current for keeping car, caravan or 4WD batteries topped up. Ideal for portable situations where temporary charging might be needed, such as campsites. Includes croc clips and car accessory plug. Size: 977Lx342Wx22Dmm.

N 0700

$22 SAVE 25%

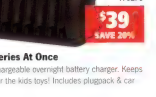
Keep your car or boat battery in top condition!

This 5W trickle charger helps extend the life of your battery during periods of inactivity. Could save you big $$$ on replacement batteries. ≈100mA charge rate. Connects via car accessory socket or croc clips. Size: 35x13cm. Not designed to charge dead flat batteries.

Weatherproof Battery Bank

Must have for tradies, travellers and hikers. Water and dust proof battery bank to recharge your phone on the go! 5V 1A output, 5600mAH.

Ideal for tradespeople



D 0508

$64.95 NEW!

A 0276

Use at home or in the car!

$39 SAVE 20%

Charge Up To 12 Batteries At Once

10 x AA/AAA and 2 x 9V rechargeable overnight battery charger. Keeps plenty of batteries charged for the kids toys! Includes plugpack & car socket adaptor.

Laptop & USB Car Charger

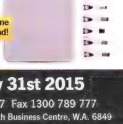
This compact supply simply plugs into a car accessory socket & provides regulated power to a laptop. Selectable voltages: 15, 16, 18, 19, 20, 22 and 24VDC, up to 120W. Supplied with 8 adaptors to suit most laptops.

$44 SAVE 20%

M 8627A

Car/240V Laptop Power Supply

A laptop power supply designed for both 240V mains and portable 12V use. Includes car power adaptor, mains lead and 12 tips to suit popular models of laptop. 14.5 to 24V output @ 90W max.



$79 SAVE $20

Works at home or on the road!

M 8990

Modified sine wave

You Save 20%

Mains Power From Your Car Battery!

Suitable for use with laptops, TVs, battery chargers, stereos & power tools. • Modified sine wave • Host of protection features • Soft start • High/low voltage shutdown

Great for camping, farmers, mobile tradespeople, service vans etc.	Rating	Part	Normally	Now...
	12V 150W	M 8072	$49.95	$39
	12V 300W	M 8076A	$69.95	$55
	12V 600W	M 8084	$149	$119
	12V 1000W	M 8090	$249	$199

$199 SAVE $100

N 1085

Backup Solar Power Anywhere, Anytime!

An excellent backup power source for those off-road adventures. In-built 3 stage solar regulator keeps batteries at peak performance. 85 Watt panel with 12V nominal output. Fitted with adjustable stand. Unfolded size: 632x541x35mm. **Includes 4m connection lead and carry bag.**

Protect your battery investment

These battery desulphators prevent sulphation from occurring on the plates of your battery - a primary cause of premature battery failure. These modules help minimise, even partially reverse sulphation. Suits standard and SLA type batteries.

Easy in-line hook up

Suits...	Part	RRP
12V under 70Ah	M 8540	$49.95
12V over 70Ah	M 8542	$59.95
24V all capacities	M 8544	$69.95

HPM® Dual 4.2A USB Charger

Dual 2.1A USB outputs for charging two tablets at once. Fitted with 1m mains lead for easy connection on your desk or table.

M 8885

$28.95 NEW!

3A Multi Voltage Power Pack

Great for appliances with high current draw such as comms/IT equipment. Voltages: 5, 6, 7.5, 9, 12, 13.5, 15V. Output at 13.5 & 15V settings ≈2.4A. Includes mains lead.

M 8987A

$36 SAVE 15%

Resellers

WESTERN AUSTRALIA

Esperance	Esperance Comms.	(08) 9071 3344
Geraldton	ML Communications	(08) 9965 7555
Kalgoorlie	Comm Systems	(08) 9091 9078

VICTORIA

Bairnsdale	Bairnsdale Electrics	(03) 5152 3201
Beaconsfield	Energy Connections	(03) 9768 9420
Bendigo	Interact Us	(03) 5444 3000
Castlemaine	Top End Technology	(03) 5472 1700
Clayton	Rockby Electronics	(03) 9562 8559
Cranbourne	Bourne Electronics	(03) 5996 2755
Croydon	Truscott's Electronics	(03) 9723 3860
Geelong	Music Workshop	(03) 5221 5844
Healesville	Amazon DVDs	(03) 5962 2763
Hoppers Crossing	Kondas	(03) 9931 0845
Leongatha	Gardner Electronics	(03) 5662 3891
Nunawading	Semtronics	(03) 9873 3555
Preston	Preston Electronics	(03) 9484 0191
Sale	Powered Solutions	(03) 5143 1060
San Remo	Shorelec Elec. W'sale	(03) 5678 5361
Somerville	AV2PC	(03) 5978 0007
Wodonga	Exact Computers	(02) 6056 5746

TASMANIA

Hobart	Active Electronics	(03) 6231 0111
Launceston	Active Electronics	(03) 6334 7333

QUEENSLAND

Bowen Hills	Prime Electronics	(07) 3252 7466
Cloncurry	Access Electronics	(07) 4742 2590
Coorparoo	Delsound	(07) 3397 8155
Fortitude Valley	Design Data	(07) 3854 1588
Gold Coast	Prime Electronics	(07) 5531 2599
Hervey Bay	Ultra Music	(07) 4128 2037
Innisfail Leading	Edge Electronics	(07) 4061 6214
Loganholme	UC Technology	(07) 3806 5111
Longreach	Access Electronics	(07) 4658 0500
Toowoomba	Michael's Electronics	(07) 4632 9990
Townsville	SOLEX	(07) 4771 4211

NEW SOUTH WALES

Brookvale	Brookvale Electrical	(02) 9938 4299
Cessnock	Leading Edge	(02) 4990 5971
Cobar	Cobar Electronics	(02) 6836 2962
Gloucester	Autolec Gloucester	(02) 6558 1600
Grafton	Downes Electronics	(02) 6642 1911
Griffith	Griffith Systems Plus	(02) 6964 5933
Gunnedah	Protronics	(02) 6742 2110
Katoomba	Aliance Electrical	(02) 4784 3361
Lawson	Aliance Electrical	(02) 4759 3366
Nth Richmond	Candle Power Tech	(02) 4571 4699
Oak Flats	Oak Flats Electronics	(02) 4256 6120
Orange	Fordray Electronics	(02) 6362 9901
Penrith	Penrith Light and Sound	(02) 4733 3333
Port Macquarie	Fettel Comms.	(02) 6581 1341
Smithfield	Chantronics	(02) 9609 7218
Tamworth	Bourke St. Electronics	(02) 6766 4664
Wagga Wagga	Wagga Car Radio	(02) 6925 6111
Waterloo	Herkes Elec. Supplies	(02) 9319 3133
Wetherill Park	Technron Electronics	(02) 9604 9710
Windang	Mad Electronics	(02) 4297 7373
Wollongong	Pro Sound & Lighting	(02) 4226 1177
Young	EWS Elec. W'sale Services	(02) 6382 6700

SOUTH AUSTRALIA

Adelaide	Aztronics	(08) 8212 6212
Brighton	Force Electronics	(08) 8377 0512
Enfield	Aztronics	(08) 8349 6340
Findon	Force Electronics	(08) 8347 1188
Kadina	Idyll Hobbies	(08) 8821 2662
Mount Barker	Home of 12 Volt	(08) 8391 3121

NEW ZEALAND

Christchurch	Riccarton Global PC	+64 3 3434475
Christchurch	Shirley Global PC	+64 3 3543333

Sale Ends January 31st 2015

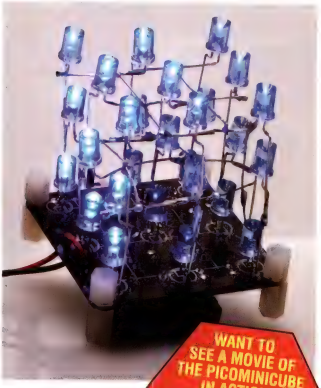
Altronics Phone 1300 797 007 Fax 1300 789 777

Mail Orders: C/- P.O. Box 8350 Perth Business Centre, W.A. 6849

Please Note: Resellers have to pay the cost of freight and insurance and therefore the range of stocked products & prices ranges from individual retailers may vary from our catalogue.

© Altronics 2015. E&OE. Prices stated herein are only valid for the current month or until stocks run out. All prices include GST and exclude freight and insurance. See latest catalogue for freight rates. All major credit cards accepted.

Your first project: a Pico Mini Cube



One of our neighbours at last September's Electronex show in Sydney was a company called PicoKit, which had a range of educational projects especially for beginners. It's been a while since we featured a real beginner's project in SILICON CHIP so with PicoKit's assistance, we're going to publish one now – and it's idealfor school holiday fun!

WANT TO SEE A MOVIE OF THE PICOMINICUBE IN ACTION? Go to siliconchip.com.au/video/picominicube

Design by Philip Tallents* Article by Ross Tester

When we say a beginner's project, the PicoMiniCube is just that, with about 20 components (mainly resistors) to solder onto a small PCB and 27 LEDs to solder together into a 3-wide x 3-deep x 3-high matrix, forming the display.

It's powered by three AA batteries and driven by a pre-programmed microcontroller, a PIC16F1503.

When finished, the PicoMiniCube gives an eye-catching display, perfect for school projects and electronics/radio club demonstrations.

Best of all, it sells for less than $30.00!

Because of the way the LEDs are soldered together, you'll gain some valuable soldering experience, not to mention component identification.

If it's not 100% perfect, it will either not work properly or not work at all!

What you'll need

First up, you'll need the PicoMiniCube kit. It's available via the PicoKit website (**www.picokit.com.au**) and sells for $26.05 (inc GST) with a pre-programmed PIC chip. If you want to (or can!) program your own PIC, the kit with an un-programmed PIC sells for $24.95 – hardly worth the hassle!

You can order it with blue LEDs, green LEDs or red LEDs. While you might be tempted to used different colour LEDs for different levels of the matrix, remember different colour LEDs have different apparent brightnesses, so the display might not look as eye-catching.

As far as tools are concerned, the requirements are pretty basic: a 30W soldering iron (with a reasonably fine tip), some electronics solder (0.7mm, rosin-cored), a pair of needle-nose pliers (fine), a pair of small side cutters and finally, a wet sponge to clean your soldering iron tip.

First of all . . .

When you open a kit, you should always check to see if all the components (parts) are there. It's most unusual to find anything missing in a kit but it's better to find out now than at 8pm on Saturday night when you can't finish the project!

Perhaps you need some help in identifying the components – we've put some illustrations in the parts list to help you there.

Next, divide the components into the various types –

resistors, capacitors, transistors, ICs (integrated circuits – there is only one in this project), and the "hardware"– sockets, connectors, the PCB, Nylon standoffs and nuts, etc.

The LEDs are normally supplied in their own bag which keeps them separate – for now, you might as well leave them in there.

Many hobbyists like to use small containers to hold the separate "bits" for projects – tiny plastic food containers, emptied(!) and cleaned, are ideal.

Or if you can get your hands on some, a scrap of polystyrene foam makes a great storage area because you can push the component leads into it!

Where a component (especially an IC) is supplied in black foam plastic, leave it in that until ready for use: the foam is actually conductive and is designed to stop static electricity damaging sensitive components.

The next step is to identify the resistor values. With young eyes, it's not too difficult to read the colour bands and so work out the values but as many colours are easy to mistake (orange and red, for example), nothing beats using a digital multimeter (on Ohms scales, of course) to get a definite reading.

Tolerance

You will almost certainly discover that a resistor is not exactly the value its colour code suggests. The band at the end of the resistor gives its "tolerance", or how close it is to its marked value. These days, it's most unlikely to be worse than 5% and more than likely better.

If its colour bands are brown, black, green and gold, that means it is 1.0 megohms (1MΩ), with the gold band meaning it is plus or minus 5% of that value – so the actual value could be anywhere between 950,000 ohms (950kΩ) and 1,050,000 ohms (1.05MΩ).

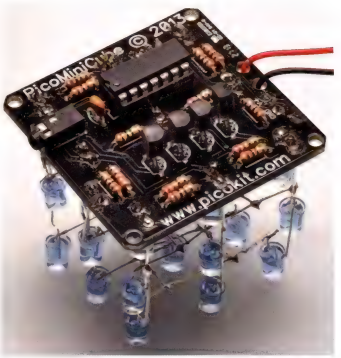
That's fine – the circuit is designed to take that variation into account. If the circuit actually needs a closer tolerance, it will say so. A 1MΩ, 1% resistor could be anywhere from 990,000 ohms (990kΩ) to 1,010,000 ohms (1.01MΩ). Even closer tolerance resistors are available but the closer they are, the more expensive they are – and, as we said before, most circuits don't need them.

Incidentally, the same comments apply to virtually ALL "passive" components – capacitors, inductors, and so on. You'll find that some components have much wider tolerances – electrolytic capacitors being a case in point with 10% and even 20% not uncommon.

Fortunately, there are only three types of resistors in this circuit – ignoring the last (tolerance) band, 100Ω (brown-black-brown), 330Ω (orange-orange-brown) and 1MΩ (brown-black-green).

In many cases, up to 1000 ohms value, the Ω symbol (or decimal point) is replaced with the letter "R" – so a 100R would mean 100Ω; 2R2 would mean 2.2Ω and so on. Above 1kΩ, the letter k serves the same purpose – 100k would mean 100,000 ohms, 4k7 would mean 4.7k or 4,700Ω. Above 1MΩ, the M symbol does the same: 1M means 1MΩ, 3M3 means 3.3MΩ, etc. In this project, the white PCB overlay is marked using this standard.

There's only one capacitor used here, a tiny 1000nF (or 1μF) ceramic type. It will probably be marked "105" – that means it is 10pF followed by five zeros or 1000000pF. Converting from pF to μF means we move the decimal point six places to the left and end up with 1.000000μF.



Most of the components solder to the top side of the PCB which becomes the underside with the LED display on top. Confused? Just remember that all components except the LEDs and on/off switch are on the side with the component overlay printed on it.

There's also only one type of transistor – a BC327 PNP switching transistor in a "TO92" case. Don't worry too much about what those numbers mean – it will all come in time!

Of all the above-board components, only the transistors and integrated circuit are polarised (ie, orientation matters on the PCB) – and we'll look at them in more detail shortly.

The "display" components, which mount under the board are the 27 LEDs, (light-emitting-diodes) which could be red, green or blue, depending on what you have ordered.

Like all diodes, LEDs are also polarised. You will note that the two legs of the LED have different lengths – the longer leg is its anode (A), while the shorter leg is its cathode (K).

Why is it K, not C? To avoid mixing it up with the "Collector" of a transistor, which has the abbreviation "C". (K stands for Kathode, the German word for . . . you guessed it!).

About the only other component, as such, is the microcontroller, a PIC16F1503 (it could be a PIC16F1505 – in this circuit, they are functionally identical).

There are loads and loads of PIC types; the 16F1503 is large enough to contain the code stored within it and has enough outputs to drive the 27 LEDs.

The code, also called the "program", can be changed by erasing it and writing new code into its memory; however, you need to know how to write programs to do so. Otherwise, once erased, it will sit there like a dumb, black, plastic thing with lots of legs!

As we mentioned earlier, the PicoKit normally comes with the PIC already programmed – and there's not much you can do which will erase it unless you specifically go about doing so – so rest easy!

The PCB (Printed Circuit Board)

The PicoMiniCube uses a double-sided board (ie, there

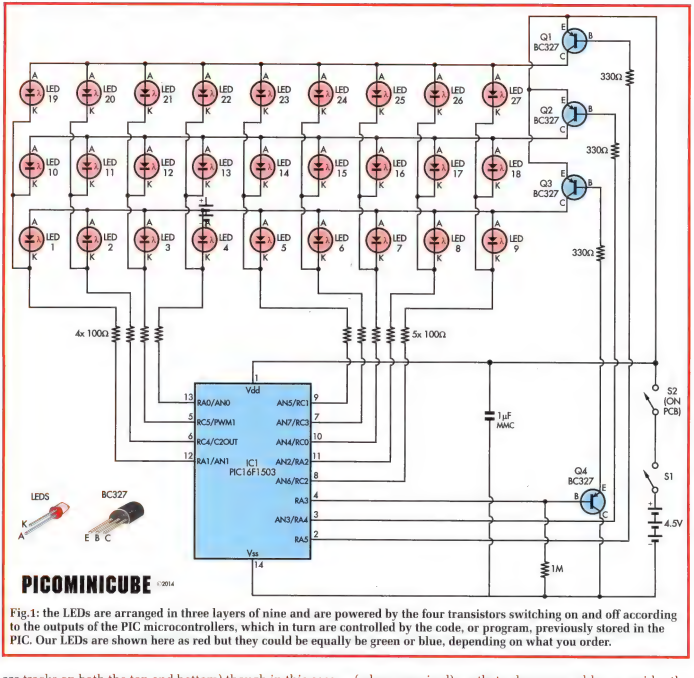


Fig.1: the LEDs are arranged in three layers of nine and are powered by the four transistors switching on and off according to the outputs of the PIC microcontrollers, which in turn are controlled by the code, or program, previously stored in the PIC. Our LEDs are shown here as red but they could be equally be green or blue, depending on what you order.

are tracks on both the top and bottom) though in this case they're quite hard to see. All the tracks are covered with a black "solder mask" which makes soldering a bit easier. But there is a downside – to see the tracks under the mask you have to hold the board so the light reflects in a certain way.

It's easy to identify the top and bottom of the board – the top side has the component positions and other information printed on it – what is known as a "component overlay" or "silk-screen overlay". (It's called that because a technique called silk-screen printing is traditionally used to print the overlay onto the PCB. It's a process that's commonly used for printing a vast array of items, probably including the T-shirt that you have on right now!)

In this particular PCB, there are also components marked on the bottom side but they are only the bottom layer of LEDs in the display and the on/off switch.

The holes in the board, into which you place the components and solder them in place, are "plated through" (where required) so that when you solder one side, the opposite side also solders.

Soldering

We've almost glossed over one of the most important parts of building this, or any other, project – soldering. Kit suppliers tell us that incorrect component placement or orientation accounts for only about one third of errors in construction. The other 90% is poor soldering!

Not only do you need to solder the LEDs together, you also need to solder components to the PCB. And some of them have pins that are pretty close together. Good soldering is a skill that all hobbyists need to develop – you need the right equipment and as mentioned earlier, the right solder.

Beginners often ask why they need to use solder especially made for electronics work and not "ordinary" solder sticks with a tin of flux, such as that used by plumbers and sheet metal workers.

How it works

The PicoMiniCube consists of two main sections: the 3 x 3 x 3 LED matrix forming the display and the circuitry to drive it, consisting mainly of a PIC microcontroller. First of all, we'll look at the 27 identical LEDs.

A light-emitting-diode, or LED, behaves in a very similar way to other diodes – that is, it conducts, or turns on, only when its anode (A) is made sufficiently positive with respect to its cathode (K). However, it has one major difference to other diodes – when it conducts, it emits light.

The colour of the light depends on the materials from which the LED is made – and you can get a wide range of colours, ranging from infrared (ie, you can't see it glow) right through all the colours of the rainbow, to ultraviolet (again, you can't see it glow but it does make many things glow themselves!).

The various colour LEDs require different voltages across them – red LEDs, for example, require a much lower voltage to make them glow than do blue. The 4.5V supply (3x AA cells) is sufficient to light any colour LED. In most cases, a resistor is necessary to limit the current through the LED, otherwise it can burn out. That's the purpose of the 100Ω resistors in series with each of the groups of LEDs in this circuit.

The LEDs are switched on and off by the microcontroller, IC1. This has been programmed with code specifically designed to power the LEDs in certain patterns. The program tells each of the output pins (pins 1-12) when to go "high" or "low" when appropriate.

On its own, the microcontroller can't supply enough current to make the LEDs glow brightly, so connected to pins 1, 2 and 3 are small PNP transistors. These act as switches, turning on and therefore supplying power from the battery to the layers of LEDs when the microcontroller sends pins 1, 2 and 3 low.

A fourth transistor, Q4, is used to supply extra power to Q3 because pin 4 cannot even handle the current necessary by itself.

If the cathodes of the LEDs were connected to the negative supply, they would light up whenever the transistors turned on. But they aren't: each LED group is connected (again via that current limiting resistor) to yet more outputs of the microcontroller.

Again, these outputs go high and low as the microcontroller program tells them to. To make the LEDs glow, the pins 5-13 microcontroller outputs need to go low at the appropriate time, so current can flow through the LEDs, through the microcontroller to the negative supply.

So to light up, the group of LEDs need one of the transistors to turn on AND the associated microcontroller output to go low – for example, when Q1 turns on because pin 2 goes low and when pin 12 goes low, LED 19 will light. If at the same time pin 13 goes low, LED 22 will light. When the transistor turns off or either microcontroller output goes high again, it/they will go dark. If pin 12 stays low but Q2 turns on, LED 10 will light.

The result of the continual switching on and off is the pattern of LEDs lighting in the PicoMiniCube whenever it is turned on. You can't control either the LEDs or the pattern – these are determined by the program. Your choices are power on or power off!

The reason is twofold: (1) plumber's solder has a much higher melting point than electronics solder. This heat could damage components and (2) ordinary soldering flux is usually quite corrosive. That doesn't matter so much with thick copper pipes, etc but in quite a short time would play havoc with the very thin copper tracks on a PCB and/or component leads.

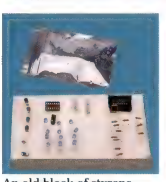
Just as importantly, electronics solder is normally supplied as a relatively fine "wire" and is much easier to handle than a stick of solder, particularly in fine work. It also usually has the flux, or rosin, running through its core – and that flux is specifically designed (it's non-corrosive) for use in electronics.

A common mistake that beginners make is to use an iron that is either too hot or too cold – either runs the risk of making a "dry joint", which often results in the solder not properly "taking" to one part or the other.

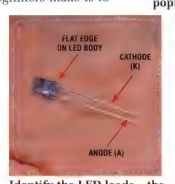
This can mean that there is no electrical connection between them from the start, or it can mean that it's a fault waiting to bite you later on when it inevitably fails.

Another common mistake, made even by those with many years experience, is to attempt to solder oxidised wires and leads. Copper (especially) but also tin and most other metals oxidise over time and solder simply will not take to them properly. If in doubt, scrape clean the lead or part to be soldered beforehand with some fine emery cloth or even a sharp hobby knife.

Solder for electronics use is normally supplied in 500g or even 1kg rolls – various gauges (thicknesses) are available but 0.7mm to 1mm are popular.

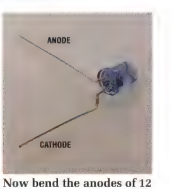


An old block of styrene foam (eg, from appliance packaging) makes component storing easy . . .



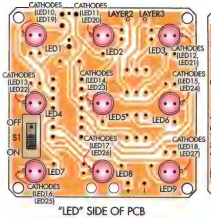
Identify the LED leads – the anode is the longer lead and there's a flat on the LED body against the cathode.

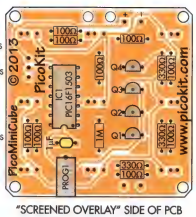
On 18 of the 27 LEDs, bend the cathode down 90° with needle-nose pliers and bend it straight 90° again.



Now bend the anodes of 12 of them 90° out in the "9 o'clock" direction. Notice the "crank" in the cathode.

There are three layers of nine LEDs, two of which are made up as shown here. The top row cathodes solder to the cathodes of the middle row (below). The middle row cathodes and both leads of the bottom layer solder to the PCB. However, to get the spacings right, you can temporarily place the LEDs in their respective spots in the PCB – but be very careful not to solder them in (yet!). The cross-connections (shown in grey) can be made up from excess component lead clippings.





We call these diagrams "component overlays" because they show precisely where all the components go on the PCB. On a single-sided PCB, its as if you are looking through the board like an X-ray, with the copper tracks underneath. The photo at right shows the same board from the component side – that is, the side which has the component positions marked on it.

Good soldering is a subject which could take many pages to explain and even then, possibly not be enough.

By far the best idea is to start with some scraps of wire and try your soldering techniques out before going anywhere near a component or PCB.

For a beginner, it's always easiest to solder the component to the PCB before cutting the excess leads off. Experienced constructors often do it the other way around, claiming a better and neater solder joint.

If you want more information, there are many, many websites which will take you through the rudiments of soldering (and even some to help make you an expert!).

Ready to start?

OK, here's the order of construction in ten easy steps:

(1) Bend the legs of the LEDs
(2) Solder 18 of the LEDs together into two layers of nine.
(3) Solder the two layers together
(4) Test that all the LEDs light using the battery pack with a 100resistor temporarily connected in series.
(5) Place and solder the components (except LEDs) on the PCB, including the PIC socket (but not the PIC!).
(6) Place and solder the bottom layer of LEDs on the PCB
(7) Solder the two layers of LEDs to the bottom layer.
(8) Connect the battery box wires to the PCB.
(9) Fit the threaded standoffs to the PCB to act as feet
(10) Fit the PIC chip in its socket

The LED matrix

Before we solder any components onto the PCB, we're going to make up the two thirds of the LED "matrix" which forms the display. The matrix eventually mounts on the underside of the PCB (ie, the non-component side) and needs to be connected as shown and described, otherwise the display won't – display, that is!

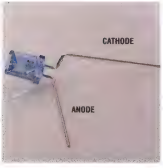
The rows are labeled Layer 2 and Layer 3 on the PCB – that's a bit confusing, so we'll refer to them as the top (layer 3), the middle (layer 2) and the bottom (layer 1).

The top layer of LEDs have their cathodes soldered to the cathodes of the layer below; later, the middle layer of LEDs will have their cathodes soldered to the PCB. The bottom layer of LEDs have both leads soldered to the PCB.

The anodes of the middle layer all connect to the point on the PCB marked "layer 2"; similarly the anodes of the top layer all connect to the point marked "layer 1".

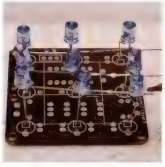
Making it!

First you'll need to bend the cathode leg of 12 of the LEDs sharply out 90° away from the LED body, nice and close to the body. Then as close as your needle-nose pliers will allow, bend it back down 90° again, so that it has a little "crank" in it – this allows the leg to pass by the body of

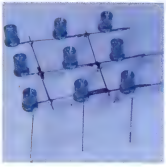


The other six LED anodes are bent out in the opposite (3 o'clock) direction. The other nine LED leads are not bent.

Keep those different types of LEDs separate! It won't work properly if they're mixed up.



Assemble each layer of LEDs by using the PCB as a template. Make sure you don't solder them in!



Connect the anodes in the top and middle layers with some component lead offcuts or hookup wire.

the LED underneath (ie, on the next layer down), where it will solder to its cathode (eg, LED 25 K connects to LED 16 K which connects to LED 7 K).

However, the anodes (A) of the LEDs aren't all the same. 12 of the LEDs are bent 90° one way while six have their anodes bent 90° in the opposite direction (see photos). These bends are to allow each LED to connect to the anode of the next LED. See how all three LEDs in the one group (ie, one row of one layer) have their anodes connected together on the circuit diagram?

It's probably easiest to follow the diagram opposite to work out where the LEDs go and which way around. See how six of the LEDs on each layer have their anode lead bent out one way while three go in opposite direction

You can use the PCB to properly space the LEDs while soldering but be careful not to solder the leads to the PCB. The flat side of the LEDs on the PCB indicate the nine CATHODES. They can be held in place by using the same block of styrene foam mentioned earlier. Solder three LEDs together, anode to anode, remove and repeat for the next three LEDs, and so on, until you've soldered all nine for the first layer.

The sets of LEDs are "cross-braced" by a pair of wires soldered anode to anode to anode. These wires can be the offcuts of component leads. Repeat for the middle layer. Now you can carefully solder the upper two layers of the cube together (see photo).

Another connection is required between the anodes on the top two layers and the PCB (the points marked "layer 2" and "layer 3"). It's probably a bit long to use component offcuts for the top layer so use the supplied short length of hookup wire. If you use uninsulated wire, make sure it touches nothing else!

Testing the cube

Once the two upper layers of the LED cube is completed, before you go any further, use the battery pack (3xAA cells) with one of the 100Ω resistors temporarily wired in series and check each of the LEDs in your cube. It might be a bit tedious but you really need to ensure that all the LEDs are soldered together correctly. Connected one way, (positive to anodes) the LED should glow. Reverse the connection and it should not.

Having satisfied yourself that the cube is all OK, you can start soldering the components onto the PCB. Remember that the components are placed onto the opposite side of the PCB compared to the LED cube but are soldered from the LED cube side. You've had plenty of practice soldering the LEDs together so soldering to the PCB should be easy!

It is usual practice to leave semiconductors until last (to minimise the chance of damaging them) and to start with the lowest-profile components, the resistors.

As mentioned earlier, there are only three values – 9 x 100Ω , 3 x 330Ω and 1 x 1MΩ . Resistors are not polarised – they can mount either direction. However, it is considered good practice to align them so they all read the same way in either the horizontal or vertical direction.

Note that while the resistors supplied in the kit were all 5% tolerance, with a gold band at the end, it is possible that 1% tolerance resistors (with a brown band) could be supplied. The easiest way to identify these is to separate the 330Ω types (first two bands are orange) then look for the single 1MΩ type – it will have brown, black, black, yellow

Parts List – PicoMiniCube

1 PicoMiniCube PCB, 50 x 50mm
1 3x AA battery holder* with switch and connecting wires
1 2.5mm stereo socket (optional – for programing if required)
1 mini PCB mounting SPDT switch
4 5mm nylon PCB standoffs (with M3 nylon nuts) – [for "feet"]

Semiconductors
1 PIC16F1503 (or PIC16F1505) programmed microcontroller

27 5mm LEDs (all same colour)

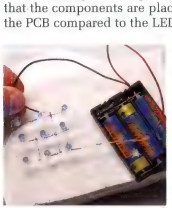
4 BC327 PNP Transistors

Capacitors
1 1µF ceramic (code: 105 or 1.0)

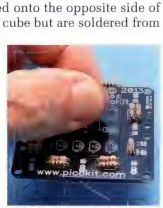
Resistors (0.25W, 5% supplied in kit)
9 100Ω (code: brown black brown gold)
3 330Ω (code: orange orange brown gold)
1 1MΩ (code: brown black green gold)

Where to get the kit:
All the components above are available exclusively in a kit from PicoKit, who hold the copyright on the design, code and PCB. It sells for $23.68 complete with programmed PIC (ref no is kit #119). Visit www.picokit.com.au for full details of this and many other Picokits to keep you busy these holidays!

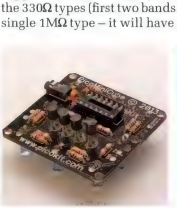
** You'll also need 3 x AA batteries (not supplied in kit)*



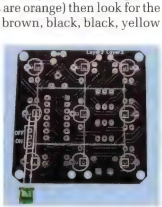
Check all of the LEDs in the layers work with the battery pack in series with a 100Ω resistor.



Start placing the components – resistors first. Check twice that they're in the right places!



Complete soldering the top side of the PCB and, once again, check that everything is in the right place.



Solder the bottom layer of LEDs onto the underside of the PCB. The square on the overlay marks the anode.

and brown bands. The remaining nine resistors would of course be the 100Ω types: brown black black brown.

Next, solder in the single capacitor – it too is not polarised so can go into the PCB either way.

Follow the capacitor with the PIC socket (but without the PIC itself). While the socket itself is not polarised, the PIC chip which plugs into it certainly is! The socket has a notch in one end which matches the notch on the PCB. Be careful soldering the pins of the socket – they're quite close together and it's easy to bridge across adjacent pins. This will either prevent the PIC working properly or, at worst, could destroy it.

The PIC programming port can go in next, although if you don't know how to program a PIC, this can be left out – it plays no part in the operation of the circuit.

Next come the four PNP transistors. Their orientation is clearly shown on the PCB – one side is curved and the other flat. They must go in this way or they could be damaged – at best, they certainly won't work! Once again, take care soldering: their pins are very close together.

We said earlier that all components apart from the LEDs solder on what is normally the top side of the PCB – but there is an exception. That's the tiny on-off switch which can now be placed on the opposite side (it doesn't matter which way around) but soldered from the top sides.

Finally, you need to connect the red and black power supply wires from the battery holder onto the board. First, pass both these wires down through one of the two larger holes alongside their solder pads then back up again through the other hole, from underneath the board – this take the strain of the flexible wires so they will have less tendency to break off at the solder joints. The red wire then solders down through the "V+" pad and the black down through the "GND" pad.

You may be wondering why this is called "GND" or ground – in battery circuits, it is generally assumed that the negative terminal from the battery is at ground potential, or 0V. Often you'll see this referred to as "Earth", perhaps with an earth symbol (⏚). Often, the terms are interchangeable (but not always – there are exceptions sometimes!).

Plug in the PIC

All that remains now is to plug the PIC16F1503 chip into its socket. If you look carefully at the chip, you see it has a notch at one end which matches the notch on the socket. Align the chip over the socket so the notches match and very carefully push the chip in, taking a lot of care that you get all the pins into the socket and not bent underneath or splayed outside.

The battery box

It's easy to damage the battery box getting the lid off. There are two clips at one end which must be VERY gently prised out to clear the locating lugs underneath. This can be done with a very small screwdriver or a hobby knife (careful!). Don't bend them too far or they will break off.

Put three AA batteries in the box in the polarity shown and place the lid back on, snapping it in place.

Turn the power switch on the battery box to the ON position and similarly turn the power switch on the PCB to ON. (It's a bit of a trap having two switches – it's probably better to leave the one on the PCB on all the time).

You should now be rewarded with all the LEDs lighting in sequence, then repeating. Congratulations!

Uh-oh . . . It's not working!

If it either doesn't work at all, or if only some of the LEDs light up, there is obviously a problem somewhere.

First thing to check is the batteries – if you measure across the V+ and GND terminals on the PCB, you should get very close to 4.5V (assuming standard AA batteries). If you get zero, make sure the switch on the battery box is on and the batteries are all seated properly. If this still gets you nowhere, check that each battery is delivering about 1.5V.

If you did get 4.5V, make sure the switch on the PCB is on. If it is and the LEDs aren't flashing, there is obviously an error somewhere. Check your soldering and the placement and orientation of polarised components.

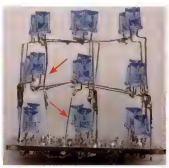
Make sure the PIC16F1503 is inserted in its socket correctly (ie, the right way around) and no pins have missed their correct positions.

If you get some LEDs flashing and others not, the chances are that one or more LEDs is the wrong way around or there's a bad solder joint on the PCB – probably one of the transistors or one of the resistors. You can troubleshoot which component(s) might be suspect by tracing back from the unlit LEDs to the PCB.

Because there are so few components, there's not much that can be wrong. If all the components are soldered in properly, are in the right place and where necessary oriented correctly, it works. If not, it doesn't! SC

*Phil ip Tallents is Manager and Product Designer at PicoKit (www.picokit.com.au)

Connect all the middle layer cathodes to the PCB – both of the arrowed holes in the PCB are for cathodes.



Join the top and middle layer anodes to the PCB - middle to position "layer 2" and top to "layer 3".

Run the battery wires down and back up again through the strain relief holes and solder to the correct pads.

Plug in the PIC chip, making sure it goes in the right way around (align the notch on the chip & socket).

SILICON CHIP ONLINESHOP

PCBs and other hard-to-get components now available direct from the Silicon Chip OnlineShop

NOTE: PCBs from past ~12 months projects only shown here but the Silicon Chip OnlineShop has boards going back to 2001 and beyond. For a complete list of available PCBs, back issues, etc, go to *siliconchip.com.au/shop* Prices are PCBs only, NOT COMPLETE KITS!

TINY TIM POWER SUPPLY	DEC 2013	18110131	$10.00
BELLBIRD	DEC 2013	08112131	$10.00
PORTAPAL-D MAINS BOARDS (for CLASSIC-D DC/DC Converter board see Nov 2012/May 2013)	DEC 2013	01111131-3	$35.00/set
LED PARTY STROBE (also suits Hot Wire Cutter [Dec 2010])	JAN 2014	16101141	$7.50
BASS EXTENDER Mk2	JAN 2014	01112131	$15.00
LI'L PULSER Mk2 Revised	JAN 2014	09107134	$15.00
10A 230VAC MOTOR SPEED CONTROLLER	FEB 2014	10102141	**$12.50**
NiCAD/NiMH BURP CHARGER	MAR 2014	14103141	$15.00
RUBIDIUM FREQ. STANDARD BREAKOUT BOARD	APR 2014	04105141	$10.00
USB/RS232C ADAPTOR	APR 2014	07103141	$5.00
MAINS FAN SPEED CONTROLLER	MAY 2014	10104141	$10.00
RGB LED STRIP DRIVER	MAY 2014	16105141	$10.00
HYBRID BENCH SUPPLY	MAY 2014	18104141	$20.00
2-WAY PASSIVE LOUDSPEAKER CROSSOVER	JUN 2014	01205141	$20.00
TOUCHSCREEN AUDIO RECORDER	JUL 2014	01105141	$12.50
THRESHOLD VOLTAGE SWITCH	JUL 2014	99106141	$10.00
MICROMITE ASCII VIDEO TERMINAL	JUL 2014	24107141	$7.50
FREQUENCY COUNTER ADD-ON	JUL 2014	04105141a/b	$15.00
VALVE SOUND SIMULATOR PCB	AUG 2014	01106141	$15.00
VALVE SOUND SIMULATOR FRONT PANEL (BLUE)	AUG 2014	01106142	$10.00
TEMPMASTER MK3	AUG 2014	21108141	$15.00
44-PIN MICROMITE	AUG 2014	24108141	$5.00
OPTO-THEREMIN MAIN BOARD	SEP 2014	23108141	$15.00
OPTO-THEREMIN PROXIMITY SENSOR BOARD	SEP 2014	23108142	$5.00
ACTIVE DIFFERENTIAL PROBE BOARDS	SEP 2014	04107141/2	$10/SET
MINI-D AMPLIFIER	OCT 2014	01110141	$5.00
COURTESY LIGHT DELAY	OCT 2014	05109141	$7.50
DIRECT INJECTION (D-I) BOX	OCT 2014	23109141	$5.00
DIGITAL EFFECTS UNIT	OCT 2014	01110131	$15.00
DUAL PHANTOM POWER SUPPLY	NOV 2014	18112141	$10.00
REMOTE MAINS TIMER	NOV 2014	19112141	$10.00
REMOTE MAINS TIMER PANEL/LID (BLUE)	NOV 2014	19112142	$15.00
ONE-CHIP AMPLIFIER	NOV 2014	01109141	$5.00
TDR DONGLE	DEC 2014	04112141	$5.00
MULTISPARK CDI FOR PERFORMANCE VEHICLES	DEC 2014	05112141	$10.00
CURRAWONG STEREO VALVE AMPLIFIER MAIN BOARD	DEC 2014	01111141	$50.00
CURRAWONG REMOTE CONTROL BOARD	DEC 2014	01111144	$5.00
CURRAWONG FRONT & REAR PANELS	DEC 2014	01111142/3	$30.00/set

NEW THIS MONTH:

CURRAWONG CLEAR ACRYLIC COVER	JAN 2015	$25.00
ISOLATED HIGH VOLTAGE PROBE	JAN 2015 04108141	$10.00

Prices above are for the Printed Circuit Board ONLY – NO COMPONENTS OR INSTRUCTIONS ETC ARE INCLUDED! P&P for PCBs (within Australia): $10 per order (ie, any number)

PRE-PROGRAMMED MICROS

Price for any of these micros is just $15.00 each + $10 p&p per order#

As a service to readers, *Silicon Chip OnlineShop* stocks microcontrollers and microprocessors used in new projects (from 2012 on) and some selected older projects – pre-programmed and ready to fly!

Some micros from copyrighted and/or contributed projects may not be available.

PIC12F675-I/P	UHF Remote Switch (Jan09), Ultrasonic Cleaner (Aug10), Ultrasonic Anti-fouling (Sep10), Cricket/Frog (Jun12) Do Not Disturb (May13)
PIC16F1507-I/P	IR-to-UHF Converter (Jul13), UHF-to-IR Converter (Jul13) PC Birdies ^2 chips – $15 pair^ (Aug13)
PIC16F688-E/P	Wideband Oxygen Sensor (Jun-Jul12) Hi Energy Ignition (Nov/Dec12), Speedo Corrector (Sept13), Auto Headlight Controller (Oct13) 10A 230V Motor Speed Controller (Feb14)
PIC16F688-I/P	Projector Speed (Apr11), Vox (Jun11), Ultrasonic Water Tank Level (Sep11), Quizzical (Oct11) Ultra LD Preamp (Nov11), 10-Channel Remote Control Receiver (Jun13), Revised 10-Channel Remote Control Receiver (Jul13), Nicad/NiMH Burp Charger (Mar14) Remote Mains Timer (Nov14)
PIC16LF88-I/P	Garbage Reminder (Jan13), Bellbird (Dec13)
PIC16LF88-I/SO	LED Ladybird (Apr13)
PIC16F877A-I/P	6-Digit GPS Clock (May-Jun09), Lab Digital Pot (Jul10) Semtest (Feb-May12)
PIC18F2550-I/SP	Batt Capacity Meter (Jun09), Intelligent Fan Controller (Jul10)
PIC18F45K80	USB Power Monitor (Dec12)
PIC18F4550-I/P	GPS Car Computer (Jan10), GPS Boat Computer (Oct10)
PIC18F14K50	USB Mini Matrix (Jul11)
PIC18F27J53-I/SP	USB Data Logger (Dec10-Feb11)
PIC18LF14K22	Digital Spirit Level (Aug11), G-Force Meter (Nov11)
PIC18F1320-I/SO	Intelligent Dimmer (Apr09)
PIC32MX795F512H-80I/PT	Maximite (Mar11), miniMaximite (Nov11), Colour Maximite (Sept/Oct12), Touchscreen Audio Recorder (Jun/Jul 14)
PIC32MX170F256B-50I/SP	Micromite Mk2 (Jun15) – *also includes **FREE** 47µF tantalum capacitor.*
PIC32MX170F256D-50I/PT	44-pin Micromite Mk2 (Now with Mk2 Firmware at no extra cost)
PIC32MX250F128B-I/SP	GPS Tracker (Nov13) Micromite ASCII Video Terminal (Jul14)
PIC32MX470F512H-I/PT	Stereo Audio Delay/DSP (Nov13), Stereo Echo/Reverb (Feb 14), Digital Effects Unit (Oct14)
dsPIC33FJ128GP802-I/SP	Digital Audio Signal Generator (Mar-May10), Digital Lighting Controller (Oct-Dec10), SportSync (May11), Digital Audio Delay (Dec11) Level (Sep11) Quizzical (Oct11), Ultra-LD Preamp (Nov11), LED Musicolor (Nov12)
dsPIC33FJ64MC802-E/P	Induction Motor Speed Controller (revised) (Aug13)
dsPIC33FJ128GP306-I/PT	CLASSIC DAC (Feb-May 13)
ATTiny861	VHA Thermometer/Thermostat (Mar10), Rudder Position Indicator (Jul11)
ATTiny2313	Remote-Controlled Timer (Aug10)
ATMega48-20AU	Stereo DAC (Sep-Nov09), RGB LED Strip Driver (**20AU chip**) (May14)

When ordering, be sure to nominate BOTH the micro required AND the project for which it must be programmed.

SPECIALISED COMPONENTS, SHORT-FORM KITS, ETC

*P&P: FLAT RATE $10.00 PER ORDER^*

*^PCBs, COMPONENTS ETC MAY BE COMBINED (in one order) FOR $10-PER-ORDER P&P RATE^*

NEW: ISOLATED HIGH VOLTAGE PROBE - Hard-to-get parts pack: all ICs, 1N5711 diodes, LED, high-voltage capacitors & resistors:	*(Jan15)*	**$40.00**
CDI - Hard-to-get parts pack: Transformer components (excluding wire), all ICs, Mosfets, UF4007 diodes, 1µF X2 capacitor:	*(Dec 14)*	**$40.00**
CURRAWONG AMPLIFIER - Hard-to-get parts pack: LM1084IT-ADJ, KSS8603, 3 x ST7005D, 5 x blue 3mm LEDs, 5 x 39µF 400V low profile capacitors	*(Dec 14)*	**$50.00**
ONE-CHIP AMPLIFIER - All SMD parts	*(Nov 14)*	**$15.00**
DIGITAL EFFECTS UNIT WM8371 DAC IC & SMD Capacitors *[Same components also suit Stereo Echo & Reverb, Feb14 & Dual Channel Audio Delay Nov 14]*	*(Oct14)*	**$25.00**
AD8033ARZ Video Amplifier ICs (SMD) For Active Differential Probe - (Pack of 3)	*(Sept 14)*	**$12.50**
44-PIN MICROMITE Complete kit inc PCB, micro etc	*(Aug14)*	**$35.00**
MAINS FAN SPEED CONTROLLER - AOT11N60L 600V Mosfet	*(May14)*	**$5.00**
RGB LED STRIP DRIVER - all SMD parts and BSO150N03 Mosfets, does not include micro (see above) nor parts listed as "optional"	*(May14)*	**$20.00**
HYBRID BENCH SUPPLY- all SMD parts, 3 x BCM856DS & L2/L3	*(May 14)*	**$45.00**
USB/RS232C ADAPTOR MCP2200 USB/Serial converter IC	*(Apr14)*	**$7.50**
NICAD/NIMH BURP CHARGER 1 SPD15P10 P-channel logic Mosfet & 1 IPP230N06L3 N-channel logic Mosfet	*(Mar14)*	**$7.50**
LF-HF UP-CONVERTER Omron G5V-1 5V SPDT 5V relay	*(Jun13)*	**$2.00**
"LUMP IN COAX" MINI MIXER SMD parts kit: Includes: 2 x OPA4348AID, 1 x BD2057CSN, 2 x DMP2215L, 1 x BAT54S, 1 x 0.22Ω shunt	*(Jun13)*	**$15.00**
LF-HF UP-CONVERTER SMD parts kit: Includes: FSD-FSC5268-12S and SA602AD and all SMD passive components	*(Jun13)*	**$15.00**
CLASSIC DAC Semi kit – Includes three hard-to-get SMD ICs: CS8416-CZZ, CS4398-CZZ and PLL1708DBQ plus an accurate 2/7MHz crystal and ten 3mm blue LEDs with diffused lenses	*(Feb-May13)*	**$45.00**
ISL6506SP3 IGBT Used in high energy ignition and Jacob's Ladder	*(Nov/Dec12, Feb13)*	**$10.00**
2.5GHz Frequency Counter	*(Dec12/Jan13)*	
LED Kit: 3 x 4-digit blue LED displays		**$15.00**
MMC & Choke Kit: ERA-2SM+ Wideband MMC and ADCH-80+ Wideband Choke		**$15.00**
ZXCT1009 Current Shunt Monitor IC As used in DC Reverse Loop Controller/Block Switch (Pack of 2)	*(Oct12)*	**$5.00** **$7.50**

^All items subject to availability. Prices valid for month of magazine issue only. All prices in Australian dollars and included GST where applicable. **# P&P prices are within Australia. O'seas? Please email for a quote** 01/15

To Place Your Order:	INTERNET (24/7)	PAYPAL (24/7)	eMAIL (24/7)	FAX (24/7)	MAIL (24/7)	PHONE - (9-4, Mon-Fri)
	siliconchip.com.au/Shop	Use your PayPal account *silicon@siliconchip.com.au*	*silicon@siliconchip.com.au* with order & credit card details	Your order and card details to (02) 9939 2648 with all details	Your order to PO Box 139 Collaroy NSW 2097^	Call (02) 9939 3295 with order & credit card details

You can also order and pay by cheque/money order (Mail Only). ^ Make cheques payable to Silicon Chip Publications.

YES! You can also order or renew your Silicon Chip subscription via any of these methods as well!

Tektronix RSA306 USB Real Time Spectrum Analyser

Review by JIM ROWE

We have reviewed a number of USB spectrum analysers and now Tektronix has entered the market. Its RSA306 spectrum analyser hooks up to a late-model PC, laptop or tablet via a "SuperSpeed" USB 3.0 cable. Together with Tek's SignalVu-PC software, it offers virtually all the features of a real-time spectrum analyser at a fraction of the cost.

IT WAS ONLY a matter of time before Tektronix decided to take advantage of the computing power of today's PCs. Enter Tektronix' new RSA306 which basically consists of similar signal acquisition front-end hardware as in one of their high-end RSAs (real-time spectrum analyser), housed in a small (190 x 127 x 33mm, 590g) ruggedised box. It's designed to be controlled by Tek's powerful SignalVu-PC software running on a fast PC, linked via a SuperSpeed USB 3.0 cable.

It seems that the SignalVu-PC software is almost identical to the data processing firmware used in Tek's high-end RSAs – simply ported over to run under Windows 7 or 8. As a result, the RSA306-plus-SignalVu-PC combination running on a modern PC can provide a very high order of performance but at a fraction of the cost.

Recently, I had the opportunity to spend a couple of days with an RSA 306 and the Tektronix "self guided demo kit". Here's a quick run-down

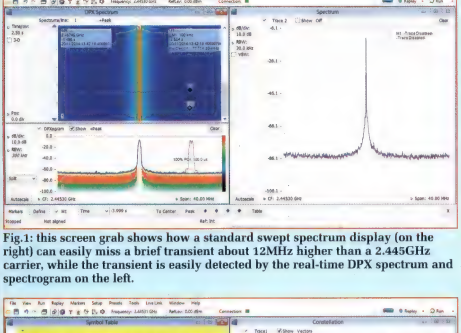


Fig.1: this screen grab shows how a standard swept spectrum display (on the right) can easily miss a brief transient about 12MHz higher than a 2.445GHz carrier, while the transient is easily detected by the real-time DPX spectrum and spectrogram on the left.

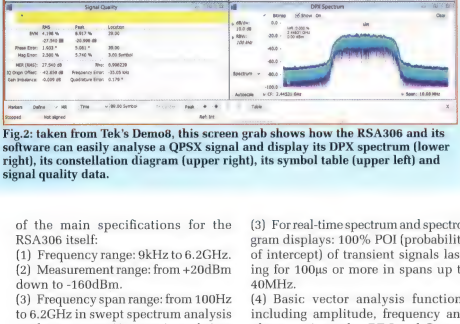


Fig.2: taken from Tek's Demo8, this screen grab shows how the RSA306 and its software can easily analyse a QPSX signal and display its DPX spectrum (lower right), its constellation diagram (upper right), its symbol table (upper left) and signal quality data.

of the main specifications for the RSA306 itself:

(1) Frequency range: 9kHz to 6.2GHz.

(2) Measurement range: from +20dBm down to -160dBm.

(3) Frequency span range: from 100Hz to 6.2GHz in swept spectrum analysis mode; up to 40MHz span in real-time DPX spectrum/spectrogram mode (both modes can be used at the same time).

And these are the main functions of the SignalVu-PC software:

(1) For standard spectrum analysis: three traces (+Peak, -Peak and average), plus a maths and spectrogram trace.

(2) Five measurement markers with power, relative power, integrated power, power density and dBc/Hz functions.

(3) For real-time spectrum and spectrogram displays: 100% POI (probability of intercept) of transient signals lasting for 100µs or more in spans up to 40MHz.

(4) Basic vector analysis functions including amplitude, frequency and phase vs time; also RF I and Q components vs time.

(5) For real-time spectrogram displays: the ability to analyse and re-analyse signals with either a 2D or 3D waterfall display.

(6) Analysis and measurement of key modulation parameters for AM, FM and PM signals, plus the ability to hear and record FM or AM demodulated audio signals to a file.

(7) Spurious signal detection and measurement using user-defined limit lines and masks, across the instrument's entire spectrum range

(8) The availability of application-specific option add-on modules for the SignalVu-PC software, covering areas such as digital modulation analysis (27 modulation types including 16/32/64/256 QAM, QPSK, O-QPSK, GMSK, FSK and APSK); WLAN analysis of 802.11a/b/g/j/p, 802.11n, and 802.11ac; mapping and signal strength; pulse analysis; and AM/FM/PM/direct audio measurements including SINAD and THD.

The demo kit consists of a 194 x 132mm PCB which can be switched to generate a wide range of different RF and baseband signals, with many different kinds of analog and digital modulation. It comes with cables to hook it up to the PC and to the input of the RSA306, plus a 104-page A5 guide book to get you going.

What makes an RSA?

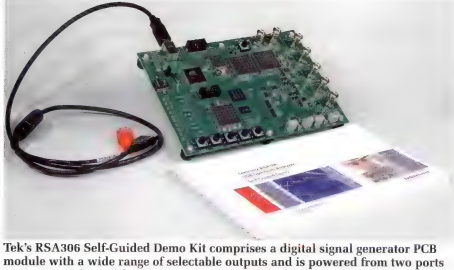
Before going any further, we should note the difference between a conventional "swept" spectrum analyser or SA/SpecAn and a real-time spectrum analyser or RSA.

Basically, a conventional spectrum analyser sweeps over a range of frequencies being examined (the "span") in sequence, taking a finite time for each sweep. This has two significant drawbacks in today's rapidly digitising world, one being that any specific frequency in the span is only examined briefly once per sweep and, of course, none of the individual frequencies is examined at exactly the same time as the others.

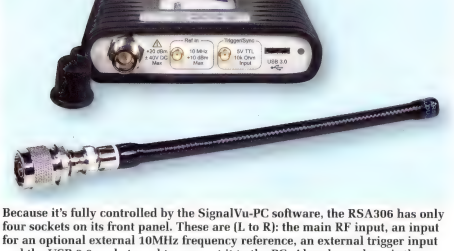
These drawbacks were of little consequence a few decades ago, when most of the signals were controlled and relatively static. But nowadays there are many situations where the signals you may want to examine are changing very rapidly in terms of amplitude, frequency or phase.

With a swept spectrum analyser, it can be surprisingly difficult to even find a briefly appearing signal, let alone capture and measure it. You may have to sweep over the frequency range concerned many hundreds of times, until it happens to show up at the exact instant that your analyser is examining that particular frequency.

An RSA gets around these problems by taking advantage of high-speed digital sampling (via an ADC) and



Tek's RSA306 Self-Guided Demo Kit comprises a digital signal generator PCB module with a wide range of selectable outputs and is powered from two ports on your PC. There's also a well-written 104-page guide book.



Because it's fully controlled by the SignalVu-PC software, the RSA306 has only four sockets on its front panel. These are (L to R): the main RF input, an input for an optional external 10MHz frequency reference, an external trigger input and the USB 3.0 socket used to connect it to the PC. Also shown here is the helical whip antenna and N-type/BNC adaptor.

digital signal processing (DSP). This allows it to sample all the signals in the frequency band being examined – simultaneously. It does this continuously, with the resulting time-contiguous stream of samples being stored in memory as well. They can be processed and analysed both during capture in real time and afterwards (from memory).

Because every signal frequency in the span range is being sampled every time, this means that an RSA can capture even very brief signals which appear anywhere in that range.

Nyquist's sampling theorem applies here just as it does anywhere else – in order to capture all frequencies in a certain frequency band, an RSA must use a sampling frequency of more than twice that bandwidth. That is why the RSA306 needs to be linked to your PC using a USB 3.0 cable, to handle the very fast stream of samples (USB 3.0 can pass data at up to 625MB/s).

What is DPX?

DPX is an acronym used by Tektronix in describing the RSA306's real-time spectrum and spectrogram display capabilities. It stands for "Digital Phosphor Analysis", a Tektronix patented technology which is built into their SignalVu firmware and software. It allows modern flat-screen displays to imitate the display persistence of CRTs which relied on a phosphor coating on the rear of the screen.

Each particle of phosphor emitted light or fluoresced when the electron beam scanned across them. And one of the advantages of CRT displays was that at least some of the phosphors could be made to persist – ie, the emitted light faded relatively slowly, allowing you to see events which lasted for a very brief time.

DPX can provide this function digitally, with added advantages like easily variable persistence time, statistical persistence functions and selectable colour schemes. So all Tektronix RSAs, including the RSA306 (or strictly speaking the SignalVu-PC software running with it) incorporate DPX, or digital persistence.

What sort of PC is needed?

The SignalVu-PC software that controls the RSA306 is pretty demanding in terms of computing power. This is the minimum PC specification required to achieve full performance:

- A PC using an Intel Core i7 4th generation processor, running either the Windows 8 or Windows 7 (SP1) 64-bit operating systems;
- At least one USB 3.0 SuperSpeed port;
- 8GB of RAM;
- At least 20GB of free space on the C: drive;
- A drive capable of streaming storage rates of 300MB/s to support the streaming data feature; and
- An internet connection for software activation.

So you do need a fairly "hot" desktop or laptop to get the best out of the RSA306. By the way, the SignalVu-PC software and all the documentation comes not on an optical disc but on a 4GB USB memory stick.

Putting it through its paces

While I've never actually driven an RSA previously and although SignalVu-PC is a complex software package, it wasn't as difficult as might be expected. This is thanks to the many kinds of continuous and semi-random signals that can be generated by the Demo Board and the clarity of the explanations of each graded demo in the guide book.

Most impressive was Demo5, where you learn how the DPX spectrum display can be used to detect and measure brief spurious signals that simply don't show up on the normal swept spectrum display – or only very occasionally. This is an excellent demonstration of the benefits of real-time spectrum analysis coupled with DPX processing.

Another very impressive demo is Demo8. This uses SignalVu's DPX spectrum function to look at a QPSK signal at 2.445GHz (from the Demo Board) and you lets you use its constellation display, symbol table and signal quality measurement displays to examine the signal in depth.

After a session with the demo board, I started using the RSA306 to examine signals from the helical whip antenna supplied with it and then with my wideband VHF-UHF discone antenna outside, the output from my GA1484B signal generator, and also the 10.000000MHz output from a GPS-disciplined PRS10 Rubidium Frequency Standard.

Before I did those tests, I screwed a 50Ω shielded wideband termination directly to the N-type input connector of the RSA306, and used this to carry out DANL/noise floor tests at 100MHz, 1.0GHz, 2.0GHz, 2.45GHz, 3.0GHz, 4.0GHz, 5.0GHz, 6.0GHz and 6.195GHz. All of these tests were done with a span of 10MHz and a resolution bandwidth (RBW) of 10Hz, a reference level of -50dBm, and averaging over 10 traces.

The DANL figures achieved were impressive, varying from -137.10dBm at 100MHz and 1.0GHz up to -136.76dBm at 5.0GHz and then down again to -138.36dBm at the very top of the range (6.195GHz, nudging the RSA306's upper limit of 6.20GHz).

There were a few tiny spurious response "spurs" visible here and there, mainly at ±4MHz points on either side of 100MHz, 1GHz, 4GHz and 5GHz. However, these were very small, varying between +0.5dB and +4.56dB in amplitude (the worst case). So the peak value of the highest spur (at 5.004GHz) was still only -132.2dBm.

When I tried using the RSA306 with its small helical whip antenna to look at the WiFi signals near my ADSL modem/wireless router, there was no trouble finding the router's "anybody there?" interrogating signal, even though there were no WiFi-linked PCs powered up at the time.

Next, I hooked the RSA306 up to the wideband discone antenna outside and tuned its centre frequency to 92.9MHz with a span of 500kHz. This showed the Sydney ABC-FM signal with a peak value of -36.8dBm. When I enabled SignalVu-PC's FM demodulation function, I could not only see the station's audio in the left-hand window but also hear it via the laptop's speakers.

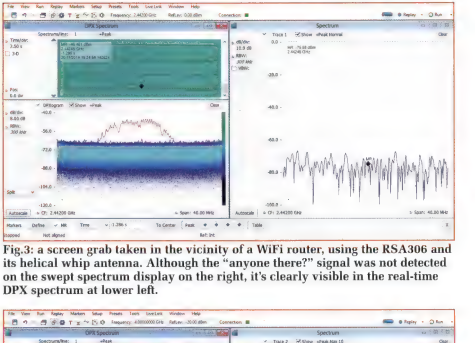


Fig.3: a screen grab taken in the vicinity of a WiFi router, using the RSA306 and its helical whip antenna. Although the "anyone there?" signal was not detected on the swept spectrum display on the right, it's clearly visible in the real-time DPX spectrum at lower left.

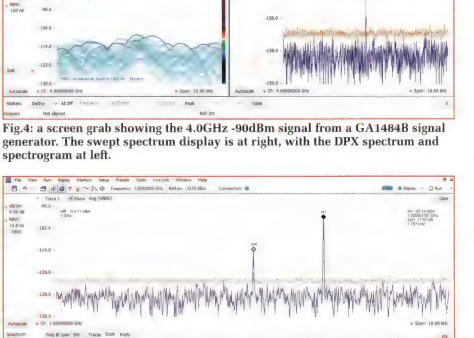


Fig.4: a screen grab showing the 4.0GHz -90dBm signal from a GA1484B signal generator. The swept spectrum display is at right, with the DPX spectrum and spectrogram at left.

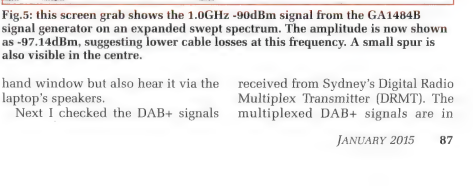
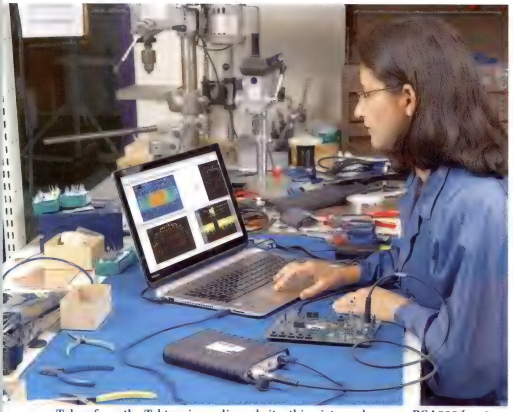


Fig.5: this screen grab shows the 1.0GHz -90dBm signal from the GA1484B signal generator on an expanded swept spectrum. The amplitude is now shown as -97.14dBm, suggesting lower cable losses at this frequency. A small spur is also visible in the centre.

Next I checked the DAB+ signals received from Sydney's Digital Radio Multiplex Transmitter (DRMT). The multiplexed DAB+ signals are in



Taken from the Tektronix media website, this picture shows an RSA306 (centre foreground) being used with the Demo Kit and a laptop running the SignalVu-PC software, in a typical workshop.

three 1.536MHz blocks, centred at 202.928MHz (Ch9A), 204.640MHz (Ch9B) and 206.352MHz (Ch9C). I had no trouble finding the three blocks and displaying their peak and average values.

I wasn't very successful in displaying the multiplex constellation diagram for any of the three but this may have been because I wasn't driving the OFDM constellation function correctly.

An unmodulated 4.0GHz signal from the GA1484B signal generator, set to give an output of -90dBm (7.1µV), was very easy to see on both of SignalVu-PC's spectrum displays, although the measured signal level was at -114dBm (446nV). This may be because I was using a 5m-long RG213 cable to connect the two, using SMA connectors and SMA-N series adaptors. At 4GHz, this cable plus the connectors and adaptors could well have significant losses.

Trying the same test at 1.0GHz, I obtained a much closer reading of -97.14dBm (about 3.15µV). However, SignalVu-PC now gave the signal frequency as 1.000001787GHz, or 1.787kHz high.

I'm pretty sure that the GA1484B's accuracy is somewhat closer than this, so I tried checking the 10MHz output from my GPS-disciplined rubidium frequency standard. This time SignalVU-PC told me that the signal frequency was 10.000014MHz. Since the rubidium standard is much closer than this, I concluded that at least part of the error was due to the accuracy of the RSA306's internal frequency reference – specified as ±25ppm + ageing (±3ppm in the first year), after a 30-minute warm-up.

By the way, the RSA306 does have provision for connecting an external 10MHz frequency reference. It also provides an external trigger input. Both of these inputs are via SMA sockets.

Fig.6: this screen grab was taken while using the RSA306 to examine the channel 9A DAB+ signal block from the Sydney DRMT (Digital Radio Multiplex Transmitter). The spectrum at right is clear but I couldn't get a clear constellation display. I can't blame the RSA306 or its software – just my poor driving!

Conclusion

Overall, I was most impressed with the Tektronix RSA306 and SignalVu-PC combination. They certainly seem to offer a level of performance approaching that of high-end real-time spectrum analysers but at a much lower price. The SignalVu-PC software is also very easy to use once you get the hang of it.

Finally, the RSA306 Self Guided Demo Kit really helps in becoming familiar with "driving" and using the RSA306 and the SignalVu-PC software. I'm sure that many buyers would appreciate a loan of the Demo Kit, or perhaps rental of one, for a week or two.

The introductory Australian price of the RSA306 is $4770 plus GST. This includes a USB3.0 cable and the SignalVU software.

Call Vicom for information on Tektronix products on 1300 360 251 or visit www.vicom.com.au or email info@vicom.com.au

Handy links:

(1) Vicom Australia: www.vicom.com.au

(2) Tektronix Spectrum Analysers: www.tek.com/spectrum-analyser A free primer titled "Fundamentals of Real-Time Spectrum Analysis" can also be downloaded from this link. SC

UBCRIBING MAKE$ ENE...

because it saves you dollars!

If you regularly purchase SILICON CHIP over the counter from your newsagent, you can $ave more than 10% by having it delivered to your mailbox. Simply take out a subscription – and instead of paying $9.95 per issue, you'll pay just $8.75 per issue (12 month subscription) – and we pay the postage!

How can we do this?

It's all about economics. Printing enough copies to send out to newsagents, in the hope that they'll sell, is very wasteful (and costly!). When readers take out subscriptions, we know *exactly* how many copies we need to print to satisfy that demand. That saves us money – so we pass the savings onto our subscribers. It really is that simple!

You REAP THE BENEFIT!

But wait, there's more! Subscribers also automatically qualify for a 10% discount on any purchases made from the SILICON CHIP online shop: books, printed circuit boards, specialised components, binders – anything except subscriptions!

So why not take out a subscription?

You can choose from 6 months, 12 months or 24 months – and the longer you go, the bigger the savings.

You can choose the print edition, the online edition or both!

Most people still prefer a magazine they can hold in their hands. That's a fact. But in this digital age, many people like to be able to read SILICON CHIP online from wherever they are – anywhere in the world. That's also a fact. NOW YOU CAN – either or both. The on-line edition is exactly the same as the printed edition – even the adverts are included. So you don't miss out on anything with the on-line edition (flyers and catalogs excepted).

OK, so how do you go about it?

It's simple: you can order your subscription online, 24 hours a day (siliconchip.com.au/shop and follow the prompts); you can send us an email with your subscription request and credit card details (silicon@siliconchip.com.au), you can fax us the same information (02) 9939 2648 (international 612 9939 2648) or you can phone us, Monday-Friday, 9am-4.30pm, on (02) 9939 3295 (international 612 9939 3295).

Don't put it off any longer: $TART $AVING TODAY with a SILICON CHIP subscription!

Salvage It!

By KEN KRANZ

This is a rather different Salvage It: We're not trying to recycle a complete device but instead, just one part of it. We're looking at Switch-Mode Power Supplies . . . and specifically, the Common-Mode Choke at the mains input. There's a lot you can do with one of these handy components.

These days, most electronic equipment has a switch-mode (or switching) power supply. They're cheaper than transformer-based (linear) supplies and you can obtain more "grunt" from a given space.

And while they're pretty reliable, they do occasionally fail (sometimes spectacularly!).

There's not much worth safely salvaging in a dead switch-mode supply – the chances are at least some of the semis (if not most/all) have failed and, given the supply's relatively high temperature operation, you wouldn't want to place too much faith in any electrolytics (check them out – we'd bet London to a brick that many would show signs of distress – especially swelling on top).

Apart from the smoke which escaped from the supply above (and there was a lot of it!) at least some of the electrolytics are showing they've failed the battle of the bulge.

But there is one component which is worth saving, if only because it is so useful in other ways. That component is the common-mode choke (CMC).

It's rare that the CMC will have failed (and that is easily checked) so it's well worthwhile to remove it before junking the rest of the SMS.

SILICON CHIP Floating Gate Drive circuits

Two projects spring to mind which had floating gate drives, employing the type of circuitry in this feature. They provide good background and reinforce the theory explained here:

(1) 200W Mains Inverter, Februaryl 1994*
(2) Courtesy Light Delay, October 2014

** some components may now be difficult to obtain*

SPICE simulations may be downloaded from siliconchip.com.au

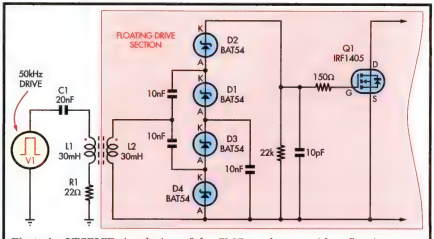


Fig.1: An LTSPICE simulation of the CMC used to provide a floating gate drive for a MOSFET. In this simulation, the voltage source (V1) at the left simulates a PIC micro with a 4.9V supply.

What's a CMC?

The attraction of CMCs is the fact that two windings are on a closed ferrite core, often with very good high-voltage insulation between the windings and low capacitance between the windings.

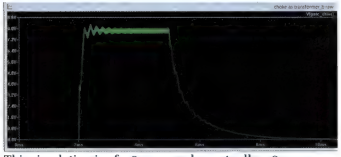
The chokes are not designed to be used as transformers but if the choke and application are selected carefully the results can be very good indeed.

First some recommendations: keep the core flux density below 1500 Gauss and limit the frequency to <75kHz. Below 20kHz most cores seem to be OK at around 2000 Gauss. To calculate the flux density use the following simple formula:

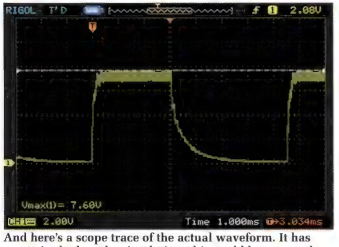
$$B_{max} = \frac{10^8 \ E}{K \ A \ N \ f}$$

B_{max} = maximum flux density in Gauss.
E = voltage across coil.
N = number of turns of the coil.
A = effective area of the coil in cm^2.
f = frequency in Hz.
K = 4.44 for sinewave (RMS).
K = 4 for squarewave (peak).

Often the number of turns can be counted or estimated (without destroying the coil). The small black 30mH CMC tested had 93 turns on each winding (one winding was unwound for this information, it was worth the sacrifice as it cost less than $1.50 on ebay).



This simulation is of a 3ms on-pulse, actually a 3 millisecond burst of 50kHz from the PIC, the waveform measurement was taken at the gate-drive test point.



And here's a scope trace of the actual waveform. It has more ripple than the simulation; this could be removed, at the expense of a longer turn-off time, by increasing the value of C2 (10pF). In the simulation, it effectively does nothing, the gate capacitance of the FET does the job – it is on the schematic to show where to add capacitance if desired. The ripple is well above the FET's gate turn on voltage so it's not actually a problem.

Actual volage drop across the 22Ω resistor.

Leakage inductance is normally higher than for a custom-wound transformer but often it is more than satisfactory for the task. The low capacitance between windings is often a big win.

It was decided to test the circuit at high power; as I do not own a 300W 10Ω resistor a simulation was carried out, again using SPICE.

A 10Ω 250W resistor and a 50V, 5A power supply were simulated, with the input signal to the CMC a 20ms burst of 50kHz (FET-on) followed by 20ms of no drive (FET-off). The FET turn-on switching loss was <3mJ, the FET turn-off switching loss was <10mJ, the power FET's loss when ON (static) was <200mW.

MISS THIS ONE?

Published in Dec 2012

2.5GHz 12-digit Frequency Counter

with add-on GPS accuracy

Wow! 10Hz – >2.5GHz in two ranges; 1µs - 999,999s with a 12-digit LED display. It's a world beater and it's the perfect addition to any serious hobbyist's bench – or the professional engineer, technician, in fact anyone who is into electronics!

You'll find it one of the handiest pieces of test gear you could ever own and you can build it yourself.

All the hard-to-get bits (PCBs, micros, LEDs, panels, etc) are available from the Silicon Chip Online Shop.

You'll find the construction details at
http://siliconchip.com.au/project/2.5ghz
PCBs, micro etc available from On-Line Shop

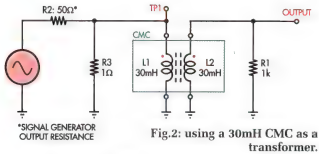


Fig.2: using a 30mH CMC as a transformer.

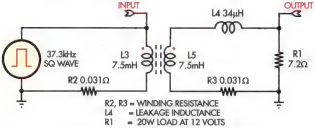


Fig.3: this time the input is a square wave at 37.7kHz but the CMC is much smaller.

The slow speed of the switching is fine for many applications – it actually keeps the RFI down.

How much drive current does this require ?

For the following test C1 was changed to 100nF to increase the gate voltage and the drive was a continuous 50.25kHz square wave from the PIC. The voltage drop was measured across the current sense resistor R1 in Fig.1.

The peak voltage was 104mV, peak current 4.7mA (0.104/22) and RMS voltage 52.2mV, so the current required to hold the high-side switch on is very reasonable.

Common mode chokes are a good choice for pulse triggering of SCRs, quite high trigger currents can be obtained with suitable chokes.

The actual measurements above were taken using a square wave drive from a PIC 16F1783. This has a super-cool PSMC (Programmable Switch Mode Controller Module) with no less than 10 modes of operation:

- Single phase
- Complementary single phase
- Push-pull
- Push-pull H-bridge
- Complementary push-pull H-bridge
- Pulse skipping
- Variable frequency fixed duty cycle
- Complementary variable frequency fixed duty cycle
- ECCP compatible modes
  - Full bridge
  - Full bridge reverse
- 3-phase 6-step PWM

The chip looked so interesting I made up some test boards.

Other uses for CMCs

If the rules regarding flux density are followed and the source impedance is low enough, CMC's can be used at low frequencies with a reasonable bandwidth, normally obtained at millivolt levels.

The primary inductance combined with the signal source impedance forms a high-pass filter. Making the source impedance low reduces this effect. The leakage inductance combined with the load on the secondary forms a low pass-filter. A higher value load resistor can be an advantage.

As a rule of thumb when using a CMC as a signal transformer, I keep the source impedance under 1/10th of the primary inductive reactance XI, calculated for the minimum frequency that is expected to be used.

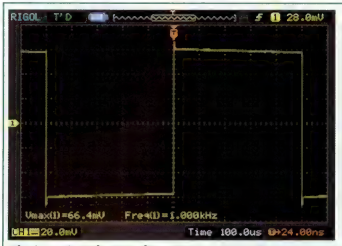
Most cores at low frequency seem to be OK with a maximum flux density of 2000 Gauss.

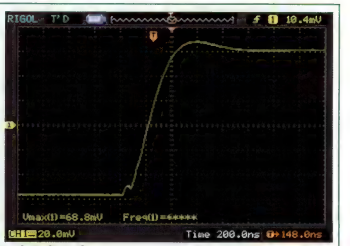
Using the 30mH CMC a circuit was set up as shown below.

At 50Hz sine wave, the maximum input voltage would be 53mV (1974 Gauss). The 50Ω resistor was used as it is built into my signal generator. With the 50Ω :1Ω voltage divider the maximum input (AC in) is 2.55VRMS.

Some tests were carried out with the signal generator set such that the input into the transformer was a 68.8mV square

You can get enough power out to run a 10W halogen globe, as seen here.

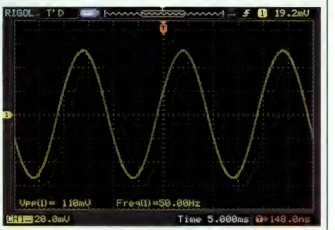




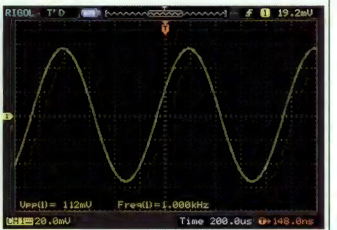
The input into the transformer was a 68.8mV square wave at 1.0kHz from the signal generator. The scope screen at left shows the 1kHz output, with a very respectable rise time (right). A gain recovery amplifier would normally be required.

Sine Wave Tests

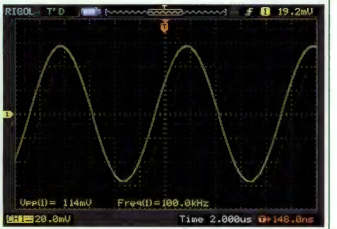
My signal generator started to clip when driven to 53.3mV RMS, so testing was carried out at 56mV peak into the transformer (across the 1Ω resistor).



50 Hz output into 1000Ω.



1kHz output into 1000Ω.



100kHz output into 1000Ω.

It can be seen apart from the low level and low-Z input the results are very handy for less than $1.50. It should be possible to run some low frequency Manchester code through these devices when low capacitance galvanic isolation is required. Even audio could be worth a try – some opamps can deliver the current required. 1kW input impedance can be very low noise for many opamps.

wave at 1000Hz, with the results shown opposite.

What about higher power?

A CMC was removed from the mains input filter of a large switched mode power supply (the one shown overleaf) that had destroyed itself, along with many major components.

The core details measured were:

Core OD	22.4mm
Core ID	14mm
Core Height	8.3mm
Core cross sectional area	35 cm^2
Measured Inductance	7.5mH
Measured Leakage inductance	35µH
Number of turns	29
DC resistance	.031Ω

A 20W halogen lamp was set up as a secondary load and a 37.3kHz square wave used as an input to the primary. After running for half an hour the CMC was warm to touch. The calculated flux density was 2116 Gauss.

It can be seen that common mode chokes can be very handy when used for applications other than their intended purpose. The construction used for the mains input types gives superb high voltage isolation.

Note: I adjusted the simulation for a 10W halogen lamp; the reduced effect of the leakage inductance allowed the input voltage to be reduced to 15.1V peak input for 12VRMS out. The output was a nicely rounded square wave. The flux density was just over 1500 gauss.

I re-ran at 25kHz, 13.9V peak input for 12VRMS at the load, with the calculated flux density 2090 gauss. SC

Radio, Television & Hobbies: the COMPLETE archive on DVD

- Every issue individually archived, by month and year
- Complete with index for each year
- A must-have for everyone interested in electronics

This remarkable collection of PDFs covers every issue of R & H, as it was known from the beginning (April 1939 – price sixpence!) right through to the final edition of R, TV & H in March 1965, before it disappeared forever with the change of name to Electronics Australia.

For the first time ever, complete and in one handy DVD, every article and every issue is covered.

If you're an old timer (or even young timer!) into vintage radio, it doesn't get much more vintage than this. If you're a student of history, this archive gives an extraordinary insight into the amazing breakthroughs made in radio and electronics technology following the war years. And speaking of the war years, R & H had some of the best propaganda imaginable!

Even if you're just an electronics dabbler, there's something here to interest you.

NB: Requires a computer with DVD reader to view – will not work on a standard audio/video DVD player

Use the handy order form included in this issue

Vintage Radio

By Associate Professor Graham Parslow

The Stromberg-Carlson 1946 model 5A26 radio

Released in 1946, the Stromberg-Carlson model 5A26 was a good-performing 5-valve superhet radio in an attractive Bakelite cabinet. The set featured here was acquired in relatively good condition and was easy to restore.

IN 1894, ALFRED STROMBERG and Androv Carlson took advantage of the fact that Alexander Graham Bell's patent for the telephone had expired. They established a firm in Chicago to manufacture telephone equipment and eight years later re-incorporated as a New York state corporation. They then diversified into other electronic products, while retaining a focus on telephone equipment.

The first US radio from Stromberg Carlson was manufactured in 1924 and it used a neutrodyne circuit designed by L. A. Hazeltine. In 1926, Stromberg-Carlson became the first manufacturer to merge phonograph and radio technology by incorporating a phonograph jack into its radio chassis.

Australian operation

Stromberg-Carlson Australia was an autonomous operation and ran its business largely independent of its American parent. The Australian company began by importing receivers from the USA in 1927. It then began local manufacture of both receivers and most of the components used in them a year later.

By 1936, production levels justified the construction of a new factory at Bourke Road, Alexandria NSW. Stromberg-Carlson subsequently made receivers and components under both their own brand name and for other brands, including Audiola and Crosley.

The 1930s represented boom years for Stromberg-Carlson's radios. During that time, the company introduced new technology such as automatic volume control, improved amplifying methods and an early pushbutton tuning mechanism. They also developed an acoustic labyrinth that was a complex baffle which improved sound quality by guiding audio waves through a series of interlocking chambers.

During the war years from 1939-1945, Stromberg Carlson produced telephones and telephone switchboards for the Australian Army. Advertisements during the 1940s proclaimed that "there is nothing finer than a Stromberg Carlson". Throughout their history, the company aimed for the high end of the market as illustrated by the 1953 advertisement reproduced with this article.

Stromberg-Carlson radios continued to sell well through the 1950s. The company then switched from valve to transistor technology and their last sets were a line of distinctive portable transistor radios clad in patterned leather. Stromberg-Carlson subsequently attempted to participate in the Australian television market but they were not competitive and all local manufacture ceased in 1961.

The 1946 model 5A26

The model 5A26 set featured here was a popular mantel radio in its time. Many have survived and the author has three examples. Unfortunately, it took all three radios to get a complete set of genuine knobs.

Basically, the knobs are unique

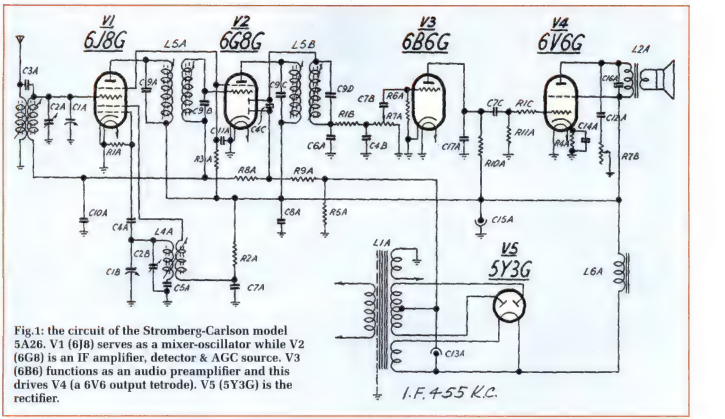


Fig.1: the circuit of the Stromberg-Carlson model 5A26. V1 (6J8) serves as a mixer-oscillator while V2 (6G8) is an IF amplifier, detector & AGC source. V3 (6B6) functions as an audio preamplifier and this drives V4 (a 6V6 output tetrode). V5 (5Y3G) is the rectifier.

to this radio because the shafts they connect to are inset within the radio and the knobs have a long moulding behind them to reach the shafts. The side knob has a longer moulding than the others to reach the top-cut tone control. The matching front knobs are for tuning and volume.

As an aside, radios with missing knobs can be a real problem for radio collectors, as genuine replacements can be difficult (if not impossible) to obtain. It was not uncommon for an owner to remove the knobs from a radio at the end of its service life (because they could be handy to keep in a junkbox), before either disposing of the set or storing it in a shed.

The radio featured here was also the only one of three to retain its front-panel badge. This badge is glued on and is often "souvenired" at the same time as the knobs. The heraldic knight featured on the badge was doubtless intended to give the impression of tradition and high class. This motif on the badge continued into the early 1950s and then disappeared when the cabinets changed from Bakelite to PVC.

The cabinet used for the set featured here is a classic brown Bakelite type. A cabinet with a rainbow of mottled colours could be purchased at slightly greater cost (see p212-213 of the book "Radio Days", by Peter Sheridan and Ritchie Singer).

Although fairly sturdy, the cabinet used for the 5A26 can also be rather brittle (especially with age) and the other two examples in my collections have cracks in them. The design is slightly different to other radios sold at the time, being somewhat longer and lower than competitive offerings. However, insetting the dial into a rounded profile at the top of the cabinet was common to many other radios of the 1940s.

The grille has the appearance of perforated metal behind the moulded bars. In reality, it's not metal but is printed cardboard with perforations to let the sound through. A thicker laminated inset of cardboard forms a baffle for the speaker and improves the bass response by acting as a seal around the speaker's frame

Circuit details

Fig.1 shows the circuit details of the Stromberg-Carlson model 5A26. It's a conventional 5-valve superhet configuration with valve V1 (6J8G) functioning as a self-oscillating mixer and V2 (6G8G) as an IF amplifier/detector/AGC stage.

The detected audio from V2 is fed to audio preamplifier stage V3 (6B6G) via volume control R7A and this then drives audio output stage V4 (6V6G). V4 in turn drives the loudspeaker via an output transformer.

Valve V5 (5Y3G) is the rectifier and this provides full-wave rectification of the centre-tapped HT secondary winding on the power transformer. The 5Y5G was a common pre-war rectifier and has a directly heated cathode which required a separate 5V transformer winding.

With an input of 240VAC, the first filter electrolytic capacitor (C13A) settles at 267V. Further HT filtering is

This is the badge used by Stromberg-Carlson on the 1946 model 5A26.

Above: the inside of the old radio looked like it had been splattered with fat but this "grease" probably came from the wax impregnation used in the power transformer and other components.

The chassis was given a thorough clean up with mineral turpentine to remove the wax and dust, while abrasive paper was used to restore the appearance of the aluminium IF-coil cans and the transformer covers.

then provided by inductor L6A and electrolytic capacitor C15A.

Note that three of the valves (V1, V2 & V3) have top-cap grid terminations, as indicated by the pin-out diagrams in Fig.2 (reproduced from the data published in the Australian Official Radio Service Manual, 1946). The loudspeaker is a Rola 5-inch permanent magnet type, so filter inductor L6A is a discrete component rather than a field coil.

In short, the set's performance is excellent, making the 5A26 a worthy addition to any radio collection.

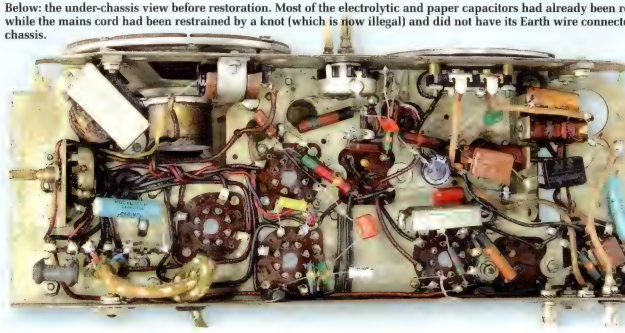
Restoration

The chassis is easy to remove from the case. Once the three knobs have been removed (by pulling them off), it's just a matter of removing two screws at the rear and then sliding the chassis (complete with speaker and dial assembly) out.

The two metal brackets over the top of the chassis are mainly there to support the glass dial and other dial assembly parts. As a bonus, they also provide a stable platform when the chassis is turned upside down for servicing.

As acquired, the old Stromberg-Carlson radio was dusty and soiled and it was tempting to clean it before testing it. However, I have found by experience that this can inadvertently create problems by disturbing pin connections and/or breaking fine wires, etc. In my opinion, it's always

Below: the under-chassis view before restoration. Most of the electrolytic and paper capacitors had already been replaced, while the mains cord had been restrained by a knot (which is now illegal) and did not have its Earth wire connected to chassis.



helpful to know whether or not a radio worked before cleaning it and whether any subsequent failure may be due to the cleaning process used.

This particular radio worked from first plug-in and drew a reasonable 46W, indicating that there were no disastrous failures in the filter electrolytics. The radio could be tuned using the front tuning knob but the dial pointer didn't move.

This can occur because the tuning mechanism has two driven sections: (1) a friction-geared coupling from the front panel knob that turns the tuning gang; and (2) a dial-cord arrangement driven by a drum on the tuning gang shaft and threaded around pulleys that guide the dial pointer along its path.

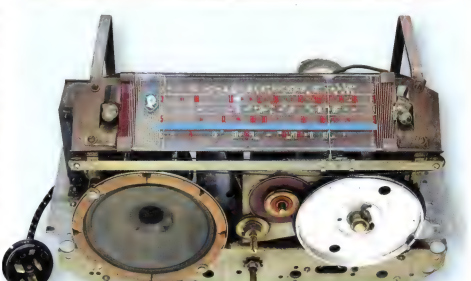
The dial cord hadn't broken but had come away from its track, so I had to figure out the correct path in order to rethread it. This was more challenging than on most radios I've tackled but I eventually got it working. The trick is to make two loops around a string-clamp to get just the right amount of spring tension.

All components on the top of the chassis looked like they had spent years next to a fry pan in a kitchen and had been splattered with fat. However, there are two pieces of evidence against this explanation: (1) the soiling was not spread across the components in a pattern consistent with splatter; and (2) another 5A26 showed identical soiling, indicating a characteristic inherent to these Stromberg-Carlson radios.

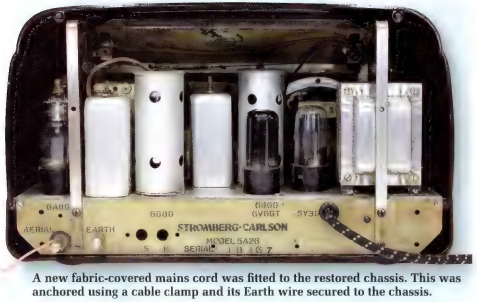
Something had apparently deteriorated into an aerosol over the years and had covered the upper chassis components. I have no idea what the source was and it was a mystery that I was happy to move on from. (**Editor's comment:** this grease may have come from the wax impregnation in the power transformer and other components. In the early days, wax was used for impregnating transformers while later production models would have used varnish impregnation. In fact, wax impregnation was still being used for high-voltage paper capacitors [in tin-plate cans] in the 1960s and 1970s).

A thorough clean-up of the chassis with mineral turpentine removed the grease and dust. Some 180 grit abrasive paper was then used to shine the aluminium IF-coil cans and clean the steel chassis. Note that although steel wool does a good job when it comes to bringing back a shining metal sur-

This advertisement for Stromberg-Carlson appeared in 1953 and illustrates the range of high-end radios and radiograms offered by the company at that time.



This view shows the chassis of the Stromberg-Carlson 5A26 after restoration. The dial cord had come away from its track and figuring out the correct path in order to restring it was one of the challenges faced in restoring this radio.



A new fabric-covered mains cord was fitted to the restored chassis. This was anchored using a cable clamp and its Earth wire secured to the chassis.

face, it should not be used to clean old radios. That's because conductive fragments can end up in odd places, particularly in the tuning gang and the speaker magnet.

For really badly-soiled low-value radios, I occasionally use a water-based degreaser. This does an excellent job in cutting away the grime but a great deal of care must be taken to protect the power transformer. It's also necessary to give the chassis sufficient time to completely dry out.

Loose grid cap

The 6G8 valve's grid cap came off while I was removing the valves, prior to cleaning the chassis. This was repaired by first tinning the small wire left protruding from the valve's glass envelope, then drilling through the top of the cap before carefully gluing it to the glass envelope with Araldite. The cap was then filled with solder via the drill hole, in order to electrically-connect it to the grid wire.

As stated above, three of the valves have top-cap grid connections. In the case of V1 & V2, these go to the tuning gang and the secondary winding of the first IF coil respectively, while V3's grid connects to the wiper of the volume control via a capacitor. These top-cap connections allow the leads to be kept short, to minimise stray capacitance.

In radios of this vintage, it's usually fair to assume that electrocution is unlikely due to accidental contact with a top connector to a valve in the RF stages because the grid voltage is low.

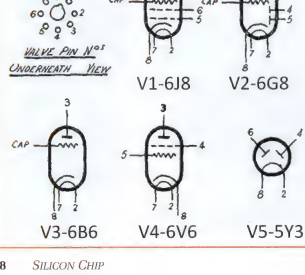
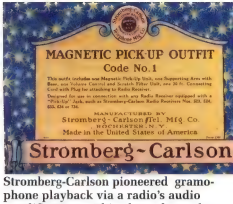


Fig.2: the pin-outs for the valves used in the 5A26. Note that three of the valves (V1-V3) have top-cap grid connections.



Stromberg-Carlson pioneered gramophone playback via a radio's audio amplifier stage. This photo shows the box-top of a 1928 add-on "Magnetic Pick-Up Outfit".

By contrast, contact with a an audio power output valve with a top-cap could well prove fatal. That's because the cap is feeding the full HT voltage to the valve's anode, as a means of avoiding arcing between its pins at the base. So err on the safe side and avoid contact with top caps – at least until you're sure that dangerous HT voltages aren't present!

Capacitor surprise

My biggest surprise with this radio came when I looked under the chassis and discovered that someone had previously replaced many of the capacitors and had done a thorough job. So despite external appearances, the radio was in remarkably good condition overall.

That was in marked contrast to another 5A26 I recently worked on where it had taken some time to establish that the 6J8 and 6V6 valves had failed, along with capacitors C7C, C11A, C13A & C17A, resistor R4A (in the cathode circuit of V4) and the speaker transformer. It's worth noting that C7C (between V3 & V4) failed only after I replaced the filter electrolytics and the HT increased. This illustrates the value of replacing all paper capacitors, particularly in high-voltage sections, to avoid progressive failures.

Finally, a replacement 3-core mains lead had been installed by the previous restorer but the earth had been left floating. The olive-green colour of that replacement cable didn't suit the set, so I substituted a black-flecked cloth-covered cable and connected the Earth lead securely to the chassis. This new cable was also clamped to the chassis, rather than using a knot inside the chassis (now illegal), as used to "restrain" the old cable. SC

ASK SILICON CHIP

Got a technical problem? Can't understand a piece of jargon or some technical principle? Drop us a line and we'll answer your question. Send your email to silicon@siliconchip.com.au

Can the Currawong be used in bridge mode?

I hope the new Currawong valve amplifier takes off. I think it will be in many constructor's budget – this is an important fact. My question is could it be run in bridge mode with a bridging adapter? (B. H., via email).

● We certainly hope the Currawong does not "take off", as in oscillate supersonically! We have tested it for stability and can state that it is unconditionally stable. Note that some old valve amplifiers could not make that claim.

As far as bridge mode is concerned, you could do that but it is not very good at driving low impedances. This means that you will get less power than you might expect in bridge mode.

Problem with links to on-line videos

I buy your magazine every month. I tried to download the video at http://youtube/AHrZgS-Gvi4 in the feature article on Argus in the December 2014 issue. "Video not available" was the response. Please send me the current URL or send me the video. (M. K., via email).

● The link does work but you have to type it exactly as it is printed. You have made a mistake in the typing of "youtu.be". Try again at http://youtu.be/AHrZgS-Gvi4 You will find it then transfers you to a secure Youtube video.

Other readers have found difficulty with a link to an oscilloscope competition on page 99 of the same issue. In that case, the problem is more subtle because the underscores in the web address have been hidden by the blue underline. The only clue is the spaces between some letters in the address.

If you frequently like to look at the websites in the magazine, you will find that all links in the on-line edition at www.siliconchip.com.au are "live". There is no need to laboriously transcribe them – you just need to click your mouse on them to make the jump to the web page.

Similarly, you will find that a lot of our advertisers have live links on their advertising in the magazine. Some even have live links embedded in photos and illustrations. If you hover the mouse over the illustration and the arrow cursor changes to a "hand" symbol, then you can click on it to go to another web page.

Multiple questions & answers

I have a number of questions which I would like to ask. I hope there are not too many for the system.

Firstly, I understand that volume control pots have a logarithmic taper and the reason for this is that it mimics the human ear's response to sound. What I don't understand is why different projects use different values for their volume control pots?

Over the years I have seen pot values of 10kΩ, 25kΩ, 50kΩ and others. What is the reason for using different values? Is it for impedance matching or is it related to the amount of current that the source signal can supply?

Secondly, I have a question about "Flaring" or "Spillover" in CRT TVs. When I studied TV theory and was repairing TVs over 20 years ago, I worked on TVs with cathode-ray tubes. Some-

Driving One Set Of Speakers With Two Amplifiers

Can you please tell me if it is safe to connect two stereo amplifiers to the same set of speakers? The amplifiers are both solid-state and will of course not be used simultaneously. (I. P., via email).

● It is definitely not safe to do this. Depending on the signal level, it could damage both the driving amplifier and the amplifier that is turned off. It is difficult to analyse exactly what would happen but perhaps the amplifier that is turned off is the one that is at greatest risk of damage.

Consider that even though it is turned off, its output transistors and the junctions of the driver transistors will definitely be affected by the presence of a large amplitude audio signal across them and heavy currents could flow. At the very least, the fuses in the driving amplifier may blow.

Of course, if both amplifiers have loudspeaker protection relays which disconnect the speakers when they are turned off, no damage may result. However, we would want to make sure that the protection relays do not short the speakers when the amplifiers are turned off.

SILICON CHIP loudspeaker protectors do, in fact, short the speakers when the amplifiers are turned off and the idea behind that is to short any heavy DC arc current which may flow if you have a catastrophic fault in the amplifier.

So in this case, protection relays in the off amplifier could damage the driving amplifier. If you tried it, the shorted outputs of the off amplifier might mean that you could be tempted to turn up the wick because no sound would emanate from the loudspeakers. That could be the coup de grace for at least one of the amplifiers.

Really, the only safe way to connect two stereo amplifiers to one set of loudspeakers would be to use a pair of changeover (ie, DPDT) relays, together with suitable switching of the relay coils using a "break before make" switch. This would ensure that only one relay could be energised at one time and would provide complete isolation between the two amplifiers.

Model Train Controller With Inertia

I have bought two 10/20A motor speed control kits (SILICON CHIP, June 1997) for use as PWM model railway controllers from the Jaycar agents in Tauranga, NZ. I was wondering about modifications to allow simulated inertia and braking by applying capacitance to the wiper of VR1.

Also, I am curious as to the effect of a dead short across the tracks (output). Is there a way to incorporate an automatically reset overload protection (say with a transistor and LED) which will protect the Mosfet and the chip? (P. O., via email).

● We published a Li'l Pulser train Controller in July 2013 with revision in January 2014. This incorporated back-EMF feedback for extra smooth running and compensation for load and incline, inertia and braking plus over current protection, forward and reverse. It is the best solution for your application. The June 1997 Motor Speed Controller is far from ideal for use as a model train controller, due to its lack of features and no overload protection which is vital in a train controller.

For the Motor Speed Controller, adding capacitance to the speed pot wiper will give a variable inertia that depends on speed pot position. Also to get realistic inertia, the capacitor would need to be 4700μF assuming a mid-position potentiometer and that is for 20s inertia. At lower speed settings, this would be considerably less.

Over-current protection could be incorporated by adding a current-sensing resistor between the Mosfet source and 0V. Then add a BC337 NPN transistor with emitter to 0V, base to the source of the Mosfet and the collector to the gate. A 0.47Ω 5W resistor would give about a 1A limit and 0.1Ω, around 4A. The 4.7Ω gate resistor would need increasing to, say, 100Ω to prevent high current in the BC337 transistor when it shunts the gate to 0V.

Values of volume controls are typically selected with an eye to the impedance of the source but another parameter which can affect the choice is to provide a low source impedance for the following circuitry, in order to minimise residual noise.

Typically, picture tubes used to flare because the cathode emission was low or the EHT supply was defective. Either way, the electron beam current was insufficient to enable an increase in brightness.

The PCB for the Little Jim AM transmitter is available from our website at www.siliconchip.com.au/Shop/8/864 Note that you also get the front panel artwork for free when you order the PCB.

Simply inserting an inductor in series with a loudspeaker, which itself has inductance, will have little apparent effect on the high frequencies. In practice, you need to use an LC filter so as well as the inductor, you also need to shunt the loudspeaker with a capacitor. Try a value of 6.8μF.

Mini-D Class-D as a headphone amplifier

The thought occurred to me that this amplifier could be used as a headphone amplifier. It is efficient and has reasonable specifications.

To do as I propose would require that the negative sides of both the left and right channel outputs are connected together to allow the usual "three terminal" connection required for normal headphones and to allow the correct phasing of the audio.

Can this be done safely without causing damage to the TPA3113D2? (R. G., via email).

● It would not be practical to do that. You can't tie the negative outputs together, as they are actively driven and the chip would detect this as a short circuit or DC fault and just shut down.

There are some rare headphones with separate wiring for both drivers or with the wires joined right at the plug. In those cases it would be practical to replace the normal headphone plug and jack socket with a 4-core shielded cable and with a 4-pin mini-DIN connector on the end.

But there is little point in doing this since the Mini-D's efficiency will be lower than normal at the low operating power required for headphones anyway. Its performance isn't particularly

times I would encounter an old picture tube. If the colour control pot and/or the contrast control was turned up too high, and sometimes even when it wasn't, I would often observe smeary colour effects.

This could present itself on a human face, for example, where instead of the edges being sharp and well defined, the colours would smear and spread out. I've always wondered what caused this fault. Is it because the phosphor dots on the inside of the picture tube have aged and are no longer sharp but respond to the electron bombardment by smearing instead?

Thirdly, I was very pleased to read about "Little Jim" (SILICON CHIP, January 2006), an AM transmitter for use with AM radios. As a member of the Historical Radio Society of Australia (HRSA), I can see the value of being able to generate AM transmissions containing old radio programs or music that can add "life" to an old radio on display or perhaps even in a workshop. Unfortunately, with the demise of RCS Radio, a PCB for this project is no longer available and therefore, this project can no longer be built.

The circuit is not particularly complex so that even if a kit wasn't released by Jaycar or Altronics, I could foresee, with access to a PCB via the SILICON CHIP Online Shop, that it could be constructed relatively easily. Are you going to produce a "Little Jim" Mk.2?

Fourth, I want to build a communications speaker that would be suitable for ham radio use. My plan would be to use an 8-ohm speaker out of a TV. I could use the 8-ohm speaker without a filter but then it would pass all frequencies which I figure would be undesirable.

As I understand it, voice frequencies cover the frequency range from 200Hz to 3kHz. Ignoring the 200Hz part, that means I need to use a low-pass filter which will only pass frequencies below 3kHz. I went to the Jaycar website and located their excellent document on the subject: *crossovr.pdf*. From that document, it appears that I should be using a 0.4 millihenry inductor in series with an 8-ohm speaker.

The inductive reactance at 3kHz is 8Ω so I figure half the signal will appear across the inductor and half will be across the speaker. Is the frequency range I quoted and my method correct? (R. F., via email).

● We will answer your questions in the order that you asked them.

good at very low power levels either. So you would be better off using a standard class-A or class-B amplifier circuit.

You could also look at the Portable Headphone Amplifier design from April 2011. That has good sound quality and low power consumption although it can suffer from RF pickup. This could be reduced by building it into a metal case to provide shielding.

While larger and more complex, our Hifi Stereo Headphone Amplifier project from the September & October 2011 issues has been very popular and is hard to go past in terms of performance. It's also somewhat easier to build, using all through-hole components and can even be used to power a small set of speakers. Its quiescent current could be adjusted down so it uses less power while still providing better sound quality than the Mini-D.

How Do Impact Drivers Develop Such High Torque?

Perhaps you can clear up a mystery for me. I was reading a Bosch power tool catalog and I was amazed by the torque which they claim that impact drivers can develop.

For example, they describe a battery-powered impact driver, Cat. GDS V-LiHT, that is an 18V 3Ah unit capable of 650Nm of torque. If you calculate what the power input is, let's say 18V x 20A, since it is only short-term, that is only 360W or only about 0.5HP.

I was further amazed by a mains-powered impact wrench, Model GDS 30, with a 1-inch (2.54mm) square drive, that develops hard/soft torques of 1000/500Nm and from "only" a 920W power rating. My car has a 120kW 2.1-litre turbo/diesel engine than "only" develops 400Nm of torque. How does this work? (I. S., via email).

● High gearing is the answer. Consider that these motors can typically run at 10,000 RPM or more and are geared down to maybe only 300 RPM for an impact driver. Furthermore, a permanent magnet motor has a very high stall torque, especially when powered by a lithium battery. Multiply this stall torque by the gearing and you have something that really does "torque"!

PIC EMI filtering in a Landcruiser

I realise that this may be an out of the ordinary enquiry but thought that I might write to you with a problem I have. After a few hints from my wife after she had been driving her Mazda 3 for a while and got used to having an external temperature display, I designed a reasonably simple circuit to display both the internal and external temperatures for our 2005 Series 100 Landcruiser.

The circuit is currently working OK on the bench and uses a Microchip PIC18F2520 running at 4MHz, two Maxim DS18B20 temperature sensors and a Fordata 8 x 2 LCD (from RS Components). I thought that I may later update it to a PIC18F4520 running at 10MHz as I could add the capability to read and display the charge currents for both the house battery in my caravan and the auxiliary battery in the car when travelling.

If I proceed with this, I intend to use Allegro ACS714 Hall effect current sensors and 433MHz transmitter/receiver modules to get the data from the caravan to the car.

My problems arose when I came to take into account the noise generated on the 12V supply leads to the PIC and the coupling into the other car wiring when the PIC communicates with the DS18B20s and the LCD – the possible effect on the other electronic parts of the car, such as computers, radio etc.

I intended to use screened cable between the sensors and display and a well-grounded diecast box housing the PIC PCB, as well as Murata chip ferrite beads and chip EMIFIL capacitor type filters on the supply and I/O lines. Unfortunately, my consideration of the use of the Murata components was short-lived when I read the Murata data sheets which stated that these components should be reflow soldered (and with special expensive alloy solders), a little more than my capabilities at home.

A possible solution could be ferrite suppression sleeves for the data lines and winding ferrite toroid cores for the supply wiring but my strength (if you could call it that) is with the micros and programming.

Now to my questions: have you ever published any articles on this subject that may be able to help me or could

Frequency Compensation In Differential Probe

I was surprised by the circuit for the Wideband Active Differential Probe in the September 2014 issue of SILICON CHIP. The surprise was that when it is switched to x10 mode and the 9MΩ resistance is added, it maintains its high-frequency response. Usually it's necessary to have a small compensation capacitor in parallel with that resistor or the high-frequency response falls off dramatically.

Usually too, it needs adjusting to an exact value on a fast-rise square-wave test to get it bang on.

I think what must have happened there, if it really does maintain a flat high-frequency response in x10 mode, is that it turned out that the capacitance of the switch was just the right value to compensate it. (H. H., via email).

● You are quite right about the switch capacitance (by sheer good fortune) providing very close to the correct shunt capacitance to provide compensation for the 10:1 range.

However that's not to say that it wouldn't be possible to "tweak up" the response on this range by fitting a small two-insulated-wires-twisted-together gimmick capacitor across each side of the switch. This could probably be done, although ideally the two gimmick compensation capacitors should really be matched to maintain the probe's differential balance.

you suggest any other articles that may help me with my design? Alternatively, could you suggest a possible solution? (K. D., Kareela, NSW).

● We haven't published any articles on this topic. The 12V supply to the PIC regulator will need to be passed through a voltage clamp such as a zener diode via a low-value resistance to prevent damage to the 3V or 5V regulator for the PIC, or you can use the LM3940 type which is rated for automotive use.

As for EMI, this is not likely to be generated by the PIC or by communication to the sensors or data lines to the LCD to any extent as the current is low, ie, in the mA range. Suppression is generally only required when higher currents are switched such as with switchmode power supplies.

You can house the circuitry in a shielded box as you mention to prevent the PIC from being affected by ignition lead interference. The use of shielded leads for the temperature sensors is a good idea.

The vehicle ECU will be fully protected from EMI and should not be affected by your circuit. The radio also will not be affected. You can use ferrite beads on the signal lines. This will round off fast switching edges and so suppress high-frequency signals sent down the wiring.

Interference from ignition system output

I work on a variety of outboard motors and one common problem that I encounter on Johnson and Evinrude outboards is that they have an over-rev mode, usually 6100RPM, built into their ignition modules. These go bad now and then and the module starts reading wrongly and will start to miss at around 4500RPM instead of 6100RPM. Therefore you have to buy a complete new CDI system.

My question is why can't there be some kind of a blocker made that could be put in line to stop or fool the module from reading the RPM? It gets its reading from the stator that charges the module. Older models never had this over-rev mode and did not have this kind of problem.

On most outboards that have this type of ignition, they recommend the use of a Champion QL prefix type spark plug which, if I am right, has to do with radio-frequency suppression and I have often wondered if this problem could occur if just standard plugs are installed.

Could the standard type of plug be sending out this radio frequency interference? (V. C., via email).

● It seems that an internal breakdown in the ignition module allows radio frequency interference (RFI) to upset the module so as to limit at the earlier 4500RPM instead of 6100RPM. If you can reduce the source of the radio signal with the RFI-reduced spark plugs then that is a good solution. Also, using radio suppressed ignition leads could also work.

Have a look at this website from which we have lifted the following salient text about RFI suppression: **www.maxrules.com/fixomcoisignition.html** It states: "There are a couple of critical items you need to be aware of on these engines. First, the spark-plug wires need to be the gray inductive resistor wires – these are not automotive wires. Secondly, the spark plugs should be the factory recommended QL78YC. Use of other spark plugs or wires can cause problems inside the power pack from RFI and MFI noise."

WARNING!

SILICON CHIP magazine regularly describes projects which employ a mains power supply or produce high voltage. All such projects should be considered dangerous or even lethal if not used safely.

Readers are warned that high voltage wiring should be carried out according to the instructions in the articles. When working on these projects use extreme care to ensure that you do not accidentally come into contact with mains AC voltages or high voltage DC. If you are not confident about working with projects employing mains voltages or other high voltages, you are advised not to attempt work on them. Silicon Chip Publications Pty Ltd disclaims any liability for damages should anyone be killed or injured while working on a project or circuit described in any issue of SILICON CHIP magazine.

Devices or circuits described in SILICON CHIP may be covered by patents. SILICON CHIP disclaims any liability for the infringement of such patents by the manufacturing or selling of any such equipment. SILICON CHIP also disclaims any liability for projects which are used in such a way as to infringe relevant government regulations and by-laws.

Advertisers are warned that they are responsible for the content of all advertisements and that they must conform to the Competition & Consumer Act 2010 or as subsequently amended and to any governmental regulations which are applicable.

MARKET CENTRE

Cash in your surplus gear. Advertise it here in SILICON CHIP

FOR SALE

PCBs MADE, ONE OR MANY. Any format, hobbyists welcome. Sesame Electronics Phone 0434 781 191. sesame@sesame.com.au www.sesame.com.au

Audio + Video: Professional quality Quest AV brand equipment is made and sold in Australia exclusively by Quest Electronics. Ph 0431 920 667. sales@questronix.com.au

tronixlabs.com - Australia's best value for hobbyist and enthusiast electronics from adafruit, DFRobot, Freetronics, Raspberry Pi, Seeedstudio and more, with same-day shipping.

PCBs & Micros: SILICON CHIP can supply PCBs and programmed microcontrollers for all recent projects. Order from our Online Shop at www.siliconchip.com.au or phone (02) 9939 3295.

PCB MANUFACTURE: single to multilayer. Bare board tested. One-offs to any quantity. 48 hour service. Artwork design. Excellent prices. Check out our specials: www.ldelectronics.com.au

LEDs: BRAND NAME and generic LEDs. Heatsinks, fans, LED drivers, power supplies, LED ribbon, kits, components, hardware, tritium markers. We can order almost anything in! www.ledsales.com.au

KIT ASSEMBLY & REPAIR

VINTAGE RADIO REPAIRS: electrical mechanical fitter with 36 years experience and extensive knowledge of valve and transistor radios. Professional and reliable repairs. All workmanship guaranteed. $10 inspection fee plus charges for parts and labour as required. Labour fees $35 p/h. Pensioner discounts available on application. Contact Alan on 0425 122 415 or email bigalradioshack@gmail.com

WORLDWIDE ELECTRONIC COMPONENTS
After 30 years am closing down, so massive price reductions to clear stock. 1/4 Watt Resistors $0.55 per 100; 0.6W 1% Metal Film Resistors $1.10 per 100; Batteries & PCB Products – Perth Metro or Pick Up Only. All other items 50% off Catalogue Price. Minimum Purchase $11.00 + Freight.
www.iinet.net.au/~worcom

KEITH RIPPON KIT ASSEMBLY & REPAIR:
* Australia & New Zealand;
* Small production runs.
Phone Keith 0409 662 794.
keith.rippon@gmail.com

ADVERTISING IN MARKET CENTRE

Classified Ad Rates: $32.00 for up to 20 words plus 95 cents for each additional word. Display ads in Market Centre (minimum 2cm deep, maximum 10cm deep): $82.50 per column centimetre per insertion. All prices include GST. Closing date: 5 weeks prior to month of sale. To book, email the text to silicon@siliconchip.com.au and include your name, address & credit card details, or phone Glyn (02) 9939 3295 or 0431 792 293.

Ask SILICON CHIP
. . . continued from page 102

You could also try adding RFI suppression on the stator lead. There are clamp-on suppression ferrite sleeves (eg, Jaycar Cat LF-1294) that may work or try adding an earthed metal shield around the ignition module. Otherwise a high-frequency inductor in line with the lead may solve the problem, eg, Jaycar LF-1400, along with a capacitor on the module side to ground. A 100nF 630V ceramic should be suitable.

Fix for relay chatter in Tempmaster

I built your temperature controller to make home brew less hit and miss in the brewing stage. It controls a small fridge and is set to 21°C and I have had a case of relay chatter which was a bit disconcerting.

I read during the year that someone else had the same problem which you cured but the writer did not elaborate on the fix. Help please as with summer coming on I do not need a bad brew. (P. G., via email).

● We are not sure which project you are referring to. It doesn't appear to be Precision Temperature Logger and Controller from the January & February 2010 issues or the High Temperature Thermometer/Thermostat from the May 2012 issue.

We think you might be referring to the Tempmaster, the latest iteration of which was in the August 2014 issue. The previous version was in February 2009. The latest version is a different circuit and it does appear to have completely solved relay chatter problems.

You can see a 2-page preview of the article at siliconchip.com.au/Issue/2014/August/The+Tempmaster+Thermostat+Mk.3

Ceramic jug element switching

I have a question about the MEN system that has been discussed in the magazine lately. Back in the 1950s, 1960s and 1970s, everyone had a china electric jug. I remember way back when I was a kid in the 1950s, I first noticed that in everyone's kitchen, the power point Active pin was always brown and in some cases even black, with bits crumbling away.

I figured back then it had to be something to do with the jug. They had a
continued page 104

Majestic Loudspeakers & A Suitable Amplifier

I have been reading SILICON CHIP magazine and came across some kits that interested me with regards to the "man cave" that I have. I have a shed where I tinker and relax and have made some additions to it but I am looking to make some more, especially with regards to the entertainment set-up.

The Majestic loudspeakers described in the June & September 2014 issues would be good in my paradise. However, I have some questions about them. I have small and large children who like to poke their fingers into everything, God bless them but they have a habit of destroying things in the process. Are there speaker grilles, corner protectors or some devices available to protect them besides placing them up high?

Then there is the question of the amplifier that would drive these speakers. I found the Ultra-LD Mk3 200W Amplifier module (SILICON CHIP, July to September 2011). Would this unit do the job to drive the speakers above or is there another unit more suitable? I live away from my neighbours so noise complaints are not on my list of priorities.

As well, I have a big screen TV, for the big matches, which has many HDMI ports and a digital audio output port. I would like to connect it to the amplifier. Do you have a preamp or a method to connect the audio from the TV to the amplifier?

Also, I have assorted iPod, DVD & CD players that have RCA plugs and Apple connectors that I would like to interconnect into the system. Is there a method to connect these devices as well? (B. D., via email).

● We agree that the Majestic loudspeakers would need protective grilles if you have children or pets, otherwise they will be damaged quite quickly. There are various 15-inch speaker grilles available which could work. For example, Jaycar has a clip-on type, Cat. AX3598.

The tweeter could potentially require protection too. It's mounted higher up and back in the horn but it might still be possible to poke a finger in and damage it. The simplest solution in that case might be to tell them not to do that!

The Ultra-LD Mk3 would be ideal for driving these speakers and there is an Altronics kit, Cat.K5125. If you don't want to spend that much money, the smaller Tiny Tim amplifier also works well. That project was published in the October 2013, December 2013 and January 2014 issues.

Our CLASSiC DAC design (February-May 2013) will convert stereo digital audio to high-quality analog signals that can then be fed to the amplifier. However you should first check if your TV has a "stereo downmix" or similar option for the digital output as this DAC can't handle compressed audio such as Dolby Digital.

It can also play music and switch between multiple digital inputs. The Ultra-LD Mk3 has three inputs but if you have more audio sources than that then you would need an external switching device.

A commercial home-theatre receiver might be a good choice too. It can do all the switching and digital-to-analog conversion and you can feed its left and right channel pre-outs (assuming it has them) to a better quality stereo amplifier.

Ask SILICON CHIP

. . . continued from page 103

wirewound element to heat the water. You could also get replacements that just had two metal plates and if you used these with rain water you had to add a pinch of salt or they would not work.

Over the years I have thought about it but cannot figure out why this should happen as there were only two wires to the jug and the jug was insulated, being china, so there was no way for extra leakage current to flow back through the Earth. So what is the explanation as to why the Neutral terminal did not also turn brown?

Maybe there is a very wise electrician out there who could explain why this occurred. (D.F., via email).

● We think you will find that the blackening of power points in those days was because people often pulled the plug straight out of the socket rather than switching off first. And if they did switch off first, the resulting arc across the switch contacts (in the Active) circuit eventually led to carbonisation around the Active terminal.

Note that if the jug boiled over (a frequent occurence), there was the possibility of leakage to Earth, particularly if the jug was close to a stainless steel kitchen sink. In fact, a boiled-over jug could give a "tingle" if it was not first turned off before being unplugged.

Also, as these jugs became older, the Bakelite lids could become partially conductive and again lead to a "tingle" from time to time. That was generally an indication that the jug needed a new lid or that it should be replaced altogether. SC

Advertising Index

4D Systems Pty Ltd 9
Altronics 72-75
Element14 5
Emona Instruments 3
Hare & Forbes ..... OBC
Icom Australia 11
Jaycar IFC,49-56
KCS Trade Pty Ltd 37
Keith Rippon 103
KitStop 9
LD Electronics 103
LEDsales 103
Microchip Technology 7
Mikroelektronika ..... IBC
Ocean Controls 6
Quest Electronics 103
Radio, TV & Hobbies DVD 93
Sesame Electronics 103
Silicon Chip Binders 101
Silicon Chip Online Shop 83
Silicon Chip PCBs 103
Silicon Chip Subscriptions 89
Silvertone Electronics 8
Trio Test & Measurement 4
Tronixlabs 103
Wabeco Australia 10
Wiltronics 59
Worldwide Elect. Components .. 103

all the inventions waiting to happen...
price: $39.00
CLICKER 2 STM32
MikroElektronika
DEVELOPMENT TOOLS | COMPILERS | BOOKS
www.mikroe.com/click
GET IT NOW
www.mikroe.com/stm32/clicker-2

HAPPY NEW YEAR 2014

Digital Calipers
- 150mm
- Hardened spring & legs

Inside Divider	Inside Caliper	Outside Caliper
~~$9.90~~	~~$9.90~~	~~$9.90~~
$8	$8	$8
(Q634)	(Q635)	(Q636)

Steel Rulers
- Easy to read graduations
- Metric on one side and imperial graduations on the reverse side

150mm/6"	300mm/12"	600mm/24"	1000mm/40"
~~$6.60~~	~~$14.30~~	~~$29.90~~	~~$26.40~~
$6	$13	$19	$24
(Q620)	(Q621)	(Q622)	(Q623)

Digital Angle Rulers
- 360° range
- Stainless steel
- Quick lock system

180mm	280mm	480mm
~~$33.00~~	~~$44.00~~	~~$49.50~~
$29	$39	$44
(M970)	(M972)	(M974)

Digital Calipers
- Metric, inch & fraction
- 4-way measuring
- Includes battery

150mm/6"	200mm/8"
~~$31.90~~	~~$49.50~~
$29	$44
(M738)	(M739)

10-124 Digital Outside Micrometer
- 0-25mm/0-1"
- Accuracy ±0.002mm
- Large LCD
- Carbide measuring faces

~~$88.00~~
$79
(Q124)

20-111 Outside Micrometer Set
- Resolution: 0.01mm
- Range: 0-75mm
- Easy adjustment for recalibrating
- Carbide tipped anvils

~~$121.00~~
$109
(Q111)

35-200 Combination Set
- 4 piece set
- 300mm / 12"
- Metric & imperial rule
- Cast iron ground finished

~~$97.00~~
$88
(Q200)

EDBD-13 Drill Sharpener
- 3-13mm or 1/8"-1/2"
- Diamond wheel
- Split point • 80W, 240V motor

~~$99.00~~
$89
(D070)

NIC Portable Video Inspection Camera - 3 Metre
- 12.5mm camera with 1M cable
- LED Lighting
- Includes 2M ext. cable, magnetic pick up, mirror tool & carry case

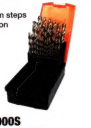
~~$165.00~~
$149
(M697)

GSP-795 Pneumatic Round Stool
- 675-795 seat height
- Ø360mm padded leather seat
- 360° seat rotation

~~$99.00~~
$89
(A359)

51 Piece Precision Jobber Drill Set - HSS
- 51 piece set
- 1-6mm in 0.1mm steps
- HSS M2 precision ground

~~$99.00~~
$89
(D1285)



170 Pieces Jobber Drill Set - HSS
- HSS precision ground flutes
- Ø1.0 - Ø10mm
- 10 drills each size up to 8mm then 5 per size

~~$185.00~~
$165
(D126)

WCH-6D + WRC-5D Workshop Series Tool Chest & Roller Cabinet Package
Ball bearing slides
Protective drawer liners
Key lockable

WCH-6D
- 6 drawer tool chest
- 600 x 260 x 340mm

WRC-5D
- 5 drawer roller cabinet
- 616 x 330 x 762mm

~~$297.00~~
PACKAGE PRICE ONLY $269 (K004)

ITEMS SOLD SEPARATELY

bts 900x Belt & Disc Linisher Sander
- 100 x 915mm belt
- Ø150mm disc
- Tilting table & mitre guide
- 370W 240V motor

~~$198.00~~
$189
(L105)

TiGer 2000S Wet Stone Grinder
- German design & technology
- 200mm stone & hone wheels
- 120W, 240V motor
- Includes straight edge jig, setting gauge & honing paste

~~$198.00~~
$189
(W859)

SBD-25A Bench Drill
- 20mm drill cap.
- 2MT, 16 spindle speeds
- Swivel & tilt table
- 1hp, 240V motor
- Includes light

~~$385.00~~
$359
(D144)

BECOME A MACHINERYHOUSE MATE

GAIN ACCESS TO:
- ONLINE PROMOS
- EXCLUSIVE OFFERS
- TRACK YOUR ORDERS
- PAPERLESS WARRANTY
- NEWSLETTERS
- LATEST RELEASES
- COMPETITIONS

+ $20 $50 $50 $70 FREE DISCOUNT VOUCHERS

SIGN UP FOR MATES RATES
MACHINERYHOUSE.COM.AU/SIGNUP

Note: Discount vouchers are valid for online purchases only

PROMO CODE
FLUX
Use promo code ONLINE OR INSTORE! to receive these special offers
Valid until 29-01-14

Specifications & Prices are subject to change without notification. All prices include GST and valid until 29-01-14

HARE & FORBES MACHINERYHOUSE

NSW	QLD	VIC	WA
(02) 9890 9111	(07) 3274 4222	(03) 9212 4422	(08) 9373 9999
1/2 Windsor Rd, Northmead	625 Boundary Rd, Coopers Plains	1 Fowler Rd, Dandenong	41-43 Abernethy Rd, Belmont

www.machineryhouse.com.au